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EDUCATIONAL PROGRESS AT HOME AND ABROAD

A recent investigation by the Federal Office of Education shows that this country, the wealthiest one in the world, has permitted the depression to curtail educational expenditures more than in approximately forty foreign countries. Some of these countries have actually increased educational budgets and extended education by carrying forward building programs and adding to the teaching force to care for the increased enrollment even though it was necessary to offset by economies in other departments and by increased taxation. Notable among these countries are the Irish Free State, France, Italy, and Mexico. The investigation shows that foreign countries realize that they cannot afford to neglect education. All teachers, and others who think, realize that the schools are a great factor in caring for the unemployed by keeping boys and girls out of the jobs men should have, and that at this time educational facilities should be expanded, not curtailed. But thinking will not produce the effect. Those who know the situation should send others the light. Teachers should educate their communities to the importance of keeping the schools functioning at full capacity. Community newspapers, parent-teacher associations, women's clubs and business men's organizations can be used to show the folly of overcrowded classes, lack of sufficient books and equipment, inferior apparatus, and worst of all, underpaid and discontented teachers. Better building material, furniture, apparatus, etc. can be obtained now and at a lower price than at any time in many years.

An intelligent, educated citizenry is both our best means for promoting good government and our greatest factor in national defense. Foreign governments are extending education facilities. We dare not curtail education if we would hold our place in world leadership.

"LET US BE SQUARE WITH OUR CHILDREN"

In a radio talk over KYW on January 3, Victor A. Olander said:

" . . . we are confronted with the problem of what some folk are pleased to call 'leisure time.' Will anyone deny the wisdom of, and indeed, the imperative need for expanding our educational facilities to meet that problem? The worker will not, and surely ought not, be content with mere 'play.' He will experience a broadening of his social and political life sufficient to arouse in him a healthy curiosity that only education will properly satisfy.

"Under such circumstances it is folly to talk of curtailing education in the United States. It must and will expand. Let us not forget, too, that in dealing with the public school system we deal chiefly with the interests of children—not merely with their monetary needs but with their future lives.

"The education which may be witheld from them now, through a curtailment of our public educational system, cannot be given to them in later years, for their childhood is short. Let us be on the square with our children, whatever the cost, and however much we may differ on other matters."

"A DICTATORSHIP OF BIG BUSINESS"

Under this caption *The School Review* for March 1933 comments on the relation of the educational situation to the demand for reduction in governmental expenditures. It is a master editorial and should be read by everyone engaged in any type of educational work. Read it and then assume the responsibility for extending its message to everyone in your community. Big business is using every means available to accomplish its ends, and it will win if educators and teachers continue passive. We must lead the fight against greed and selfishness.

ELEMENT 87 CONCENTRATION HALTED BY EXPLOSION INJURY TO FINNISH CHEMIST

Blinded completely in one eye, with his other eye weakened, and with his hearing affected, Prof. Gustave Aartovaara of the Helsingfors Technical University is a martyr to his search for a missing chemical element. In 1931 while engaged in the chemical concentration of the missing chemical element, 87, Prof. Aartovaara was the victim of a laboratory explosion, the effects of which have prevented his continuance of research.

To Prof. Fred Allison of the Alabama Polytechnic Institute, Prof. Aartovaara sent specimens that he believed contained element 87 and Prof. Allison detected this element by his magneto-optical method of analysis.—*Science Service.*

MATHEMATICS USED BY AMERICAN INDIANS NORTH OF MEXICO

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The mathematical concepts of primitive races are of interest to both the mathematician and the historian; the mathematician accepts them as indicators of the natural order of development of his subject while the historian studies them for an insight into the cultural development of the race and of mankind. A study of the habits and customs of the American Indians north of Mexico, before the intervention of the white race, brings to light many interesting instances of their use of various arithmetical and geometrical concepts and principles. Although their bonds of superstition and lack of an adequate symbolism very greatly limited their mathematical progress we find that number played a very important role in their various religious beliefs and that they made rather elaborate use of many geometric figures in ornamentation and construction.

I. Arithmetical Concepts and Principles

Sacred Numbers. Most of the Indians of North America attributed mystical properties to certain numbers. Specific reference may be found to the use of three, four, five, seven, and thirteen in the performance of religious ceremonies. Among all the different numbers so employed four seemed to be the most popular, probably due to the recognition of the four cardinal points of the compass. Five was the mystical number of some of the Pacific Coast Indians; seven was reverenced by the Zuñi, Cherokee, Creeks, and most of the Plains tribes; and thirteen, which was quite prominent in Central America, was adopted by the Hopi, Pawnee, and Zuñi.[1]

Among the *four* cults ceremonial acts were repeated in sets of four and certain rites lasted four days and nights. In the Pueblo Snake Dance the Snake Men prepared eight days for the ceremony; the snakes used were of four kinds obtained from a four days' hunt in the four directions.[2] An Apache prayed to his gods

[1] F. W. Hodge, "*Handbook of American Indians North of Mexico,*" Bulletin No. 30, Bureau of American Ethnology, Part I, Government Printing Office, Washington, D. C., (1907), p. 354.

[2] A. C. Parker, *The Indian How Book*, Doubleday, Doran, and Co., Garden City, N. Y., (1927), p. 271.

at least once every four days and if it were expedient he might pray every day, four, or any multiple of four, times a day.[3] Medicine-men of the Apache tribe often used this sacred number in their remedies; in a prescription the roots of four varieties of herbs or four roots of one herb were used. When singing, four songs were sung or one song was sung four times or any multiple of four.[4] To a person destined to become a medicine-man in the Papago tribes there came four dreams on four successive nights.[5] On the four following nights an animal appeared before him, and at the fourth appearance led the spirit of the man through four mountains, showing him the medicine to be found.

If a member of the Potawatomi tribe were accused of murder and the tribal chief thought he was not guilty, a pipe bearer with flint and steel attempted to light the chief's pipe; if he were successful in four strokes of the steel the man went free, but if he failed the accused was executed. An influential man might have escaped punishment for three murders, but if he killed four people there was nothing that could save him.[6]

Three and five were sacred numbers to the Iroquois.[7] They would take three puffs from a pipe when smoking according to ceremonial custom and only three trials were allowed in contests of skill or strength. It was necessary for five days or some multiple thereof to elapse between the announcement and the beginning of a celebration, and a grain of corn was sent as an invitation because corn sprouted five days after sowing. In the Ghost Dance of the Plains tribes the sacred number was seven and the dancers formed in groups of seven or fourteen.[8]

Many other examples of the use of mystical numbers are to be found in the legends and creation myths. These, in general, have reference to the number of repetitions of events or to intervals of a certain number of days.

Methods of Counting. The system of counting which was practically universal among the Indian tribes was that of counting on the fingers. The count began with the little finger of the left hand and proceeded to the thumb which was five. The method of numerating the second five varied, but usually the thumb of

[3] E. S. Curtis, *The North American Indian*, University Press, Cambridge, Vol. I, (1907), p. 42.
[4] *Ibid.*, pp. 36, 41.
[5] *Ibid.*, Vol. II, (1908), p. 34.
[6] W. D. Strong, The Indian Tribes of the Chicago Region, Anthropology Leaflet, 24, Field Museum of Natural History, Chicago, 1926, p. 22.
[7] J. N. B. Hewitt, "Sacred Numbers Among the Iroquois," *The American Anthropologist*, (1889) II, p. 165–166.
[8] A. C. Parker, *op. cit.*, p. 266.

the right hand was six and the little finger ten. Often the fingers were bent inward as they were counted, but some of the western tribes began with a clinched fist and opened the fingers outward. Some tribes used the toes in counting the second ten, but others continued with the fingers, designating the completion of the first ten by a clap of the hands or a wave of the right hand. The Zuñi counted the second ten on the knuckles.[9]

The Dakotas made a vertical line for a count of one and represented one hundred by one hundred such marks.[10] The Creeks also counted each vertical mark as one unit but represented ten by the sign of the cross.[11] Another use of tally marks was found in the census roll of a Mille Lac band of the Chippewa; the thirty-four families were symbolized by pictographs under which was indicated the number of persons in each family.[12]

Evidences of subtraction were found in the formation of some number words; for example, in the Bellacoola language of British Columbia:

16 = one man less four,
18 = one man less two,
26 = one man and two hands less four,
36 = two men less four.[13]

In a letter of November 17, 1893, Dr. J. Owen Dorsey called to Conant's attention a gesture of throwing the hand to the left used by some of the prairie Indians to signify multiplication.[14] A count of five followed by a wave of the hand to the left meant fifty. Traces of multiplication were found also in the construction of number words, as is exemplified by the following numbers found in the Zuñi scale:

10 = all the fingers,
20 = two times all the fingers,
100 = the fingers all the fingers,
1000 = the fingers all the fingers times all the fingers.[15]

Number systems. Although a number system with five as base might be considered the most natural development of the finger method of counting, it was quite universally the practice among

[9] F. W. Hodge, *op. cit.*, pp. 353–354.
[10] H. R. Schoolcraft, Historical and Statistical Information Respecting the History, Condition and Prospects of the Indian Tribes of the United States, J. B. Lippincott, Philadelphia, Vol. II, (1852), p. 178.
[11] *Ibid.*, Vol. I, (1851), p. 273.
[12] *Ibid.*, Vol. II, p. 222.
[13] L. L. Conant, *The Number Concept, Its Origin and Development*. The Macmillan Co., New York, (1896), p. 46.
[14] *Ibid.*, p. 59.
[15] *Ibid.*, p. 49.

these North American Indians to make use of a system of numbers whose unities grouped themselves into tens. In fact among some of the tribes, particularly those north of the Columbia River and along the Pacific Coast, the most generally employed scale was the vigesimal. Scales even more primitive than the quinary have been found and vestiges of them appear in more advanced systems. Traces of a binary scale have been discovered in the Siouan and Algonquian languages,[16] as well as evidences of a quaternary scale among the Indian dialects of British Columbia.[17]

Many of the regular systems extended to include one thousand. Larger numbers existed in the languages but it was quite often the case that they were not introduced until after contact with white people. Schoolcraft[18] illustrates the difference between a native combination and that made under outside influence by contrasting the Winnebago expression for one billion, *ho ke he hhuta hhu cheu a ho ke he ka ra pa ne za*, with that of the Choctaw, *bil yan chuffa*. There were some tribes whose numerals, were extremely limited, and quite frequently it was the fundamental formula of word combination that caused this limitation. The cumbersome nature of such a system can be seen in the combination *wick a chimen ne nompah sam pah nep e chu wink ah* which was used by the Sioux to express twenty-nine.[19] Bancroft says that the Lower Californians were unable to count more than five, though a few understood that two hands signified ten.[20] Numbers above this level were expressed by terms as "many" or "much."

An unusual number system was that of the Micmacs, in which the numerals were verbs and they were conjugated through all forms of mood, tense, person and number.[21] In the Tshimshian language of British Columbia, there were seven sets of numerals, one set used for counting under each of the following distinct classifications of objects: (1) with reference to no definite object or merely abstract counting, (2) flat objects and animals, (3) round objects and divisions of time, (4) men, (5) long objects, (6) canoes, and (7) measures.[22] The Takulli dialect of the

[16] F. W. Hodge, *op. cit.*, p. 353.
[17] L. L. Conant, *op. cit.*, p. 113.
[18] H. R. Schoolcraft, *op. cit.*, Vol. II, pp. 206, 216.
[19] *Ibid.*, p. 207.
[20] H. H. Bancroft, *The Native Races*. The Works of H. H. Bancroft, I. The History Co., San Francisco, (1886), p. 564.
[21] H. R. Schoolcraft, *op. cit.*, Vol. V, p. 587.
[22] Franz Boas, "First General Report on the Indians of British Columbia," Report of the British Association for the Advancement of Science, (1889), pp. 880–881.

Athapascan language furnishes another interesting example of the modification of the number name according to the thing counted, for example,[23]

tha = three things,	*thane* = three persons,
that = three times,	*thatser* = in three places,
thauh = in three ways,	*thailtoh* = all three things.

Very few instances of the use of a system of ordinal numbers have been found. Boas[24] found that the Tlingit tribe had an ordinal scale from *first* through *eighth*, and that they also used the numeral adverbs;

tlehaden = once,	*daqdahen* = twice,
natsk dahen = three times,	*dak'on dahen* = four times.

He also states that the Haida used ordinal numbers from *first* through *fifth*, and that the Kutonaqa had a system of numeral adverbs somewhat similar in meaning to those of the Tlingit tribe. The only reference to the use of fractions were the Kutonaqa expressions for one-half and one-third.

Methods of Reckoning Time. The two most important bases for reckoning time were the changes of the moon and the seasons, and the succession of days and nights. The moons and seasons were named for some natural phenomenon which occurred at that time. The Indians of Virginia divided the year into five seasons: *The budding of spring; the earing of corn*, or *the roasting-ear time; summer*, or *the highest sun; corn-gathering*, or *the fall of the leaf;* and *winter.*[25] Four seasons were usually recognized, although some tribes distinguished five, some two, and the Lower Californians six.[26] The Teton Sioux, in general, acknowledged only two seasons.[27] They counted twelve moons, of twenty-seven days each, in a year, and three days had to elapse after each moon before the count was resumed. In order to complete the solar year the Cree counted thirteen moons; the Haida inserted a moon between their two seasons; and the Creeks added a moon at the end of every second year, thus resulting in twelve and one-half moons in each year.[28]

Some tribes divided the day into four parts—sunrise, noon, sunset, and midnight; others, omitting midnight, had only three divisions. The Salish divided the day into nine parts ac-

[23] F. W. Hodge, *op. cit.*, p. 354.
[24] Franz Boas, *op. cit.*, pp. 857–858, 869, 890.
[25] F. W. Hodge, *op. cit.*, p. 189.
[26] H. H. Bancroft, *op. cit.*, p. 564.
[27] E. S. Curtis, *op. cit.*, Vol. III, p. 30.
[28] F. W. Hodge, *op. cit.*, p. 189.

cording to the position of the sun.[29] The Indians of South Carolina determined the time of day by the number of handbreadths the sun was above the horizon.[30] The Choctaws expressed a period shorter than a day as the length of time it took the sun to travel the distance between two parallel lines drawn on the ground.[31]

Several calendars have been found, one of the first being *Lone Dog's Winter Count* which was a product of the Dakota Indians.[32] Each figure of this calendar, which was painted on a buffalo hide, represented an outstanding event in one year. The pictographs were arranged in an outward spiral starting from a central point, and covered a period of seventy-one years. The discovery of other Dakota calendars reveals that the year-characters were arranged in straight lines and serpentine curves as well as in spirals. They counted years by winters and a man's age was recorded as "so many snows old."

Among other tribes calendars were found to employ tally marks, notches, and circles along with the pictograph for recording and reckoning time.

The arithmetic of these Indian tribes seems to have been limited to addition, simple subtraction, and in a few cases, simple multiplication with integers. Their bonds of superstition and failure to develop an adequate system of number words and symbols prevented any great amount of progress beyond the simple fundamentals.

II. GEOMETRICAL CONCEPTS AND PRINCIPLES

Indian Houses. Geometric forms were used by the Indians in the construction of their houses which were principally rectangular or circular. No definite indication as to the method of constructing right angles and circles has been found. The drawing of a circle was probably accomplished by using two stakes and a cord or strip of rawhide as a pair of compasses. MacLean found what he believed to be an incomplete circle with points on the circumference marked by small heaps of earth,[33] thus indicating that in cases where the complete circle could not be

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[29] H. H. Bancroft, *op. cit.*, p. 275.

[30] E. L. Green, The Indians of South Carolina, The University Press, Columbia, (1904), p. 45.

[31] H. B. Cushman, *History of the Choctaw, Chickasaw, and Natchez Indians*, Headlight Printing House, Greenville, Texas, (1899), p. 249.

[32] Garrick Mallery, "Pictographs of the North American Indians," Fourth Report of the Bureau of Ethnology, Government Printing Office, Washington, D. C. (1886), p. 92.

[33] W. J. McGee and Cyrus Thomas, *Prehistoric North America, The History of North America*, Vol. XIX, George Barrie & Sons, Philadelphia, (1905), p. 376.

drawn, points on the circumference were marked by special devices.

The typical dwelling of the Eastern Indians and the Plains tribes was the conical tent. The Timuqua lived in circular houses, but generally the Indian home of the southeastern section was rectangular with a curved roof.[34] A drawing by Le Moyne, 1563, portrays the Seminole Indians carrying their crops to a cylindrical storehouse which has a conical top.[35] Cyrus Thomas states that, according to Le Moyne's drawings, most of the Indian houses of Florida were circular while those farther north were oblong.[36]

The Menomini, Winnebago, Sauk, and Fox tribes occupied dome-shaped lodges in the winter and rectangular bark houses in the summer.[37] The Mandan huts were circular in form and were from forty to sixty feet in diameter; the roof was conical and the interior was divided into triangular compartments.[38] The Northern Californians built either conical or rectangular gabled houses, but their doors were always circular.[39] The Indians of Central and Southern California as well as those of the entire Southwest except for the Pueblos, built conical or dome-shaped huts. An outline of the ground plan of a Navajo hogan, given by Mindeleff, shows the circular form of the hut and within the sacred circular path which the Indians followed in their ceremonials.[40] The Pueblos lived in rectangular stone houses of the communal type. This style of architecture was preceded by the circular and it is thought by some that the rectangular form of construction used by the Pueblos was a result of crowding a large number of circular houses into a small space.[41] Another interesting rectangular variation was found among the Tlingit who built their houses upon a base which was in the shape either of a square or a parallelogram.[42]

The snow houses of some of the Eskimo bands were quite dis-

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[34] Clark Wissler, *The American Indian*, Douglass C. McMurtrie, New York, (1917), pp. 222-223.

[35] Minnie Moore-Willson, *The Seminoles of Florida*, Moffatt, Yard and Co., New York, (1911), p. 6.

[36] Cyrus Thomas, *The Indians of North America in Historic Times, The History of North America*, Vol. II, George Barrie & Sons, Philadelphia, (1903), p. 60.

[37] Clark Wissler, *op. cit.*, p. 221.

[38] George Catlin, *Letters and Notes on the Manners, Customs and Condition of the North American Indians*, Vol. I, Wiley and Putnam, New York, (1842), p. 81. Livingston Farrand, *Basis of American History*, 1500–1900. *The American Nation; A History*, Harper and Brothers, New York, (1904), p. 136

[39] Clark Wissler, *op. cit.*, p. 213.

[40] Cosmos Mindeleff, "Navajo Houses," Seventeenth Report of the Bureau of American Ethnology, Part II Government Printing Office, Washington, D. C. (1898), p. 517.

[41] F. H. Cusling, "A Study of Pueblo Pottery as Illustrative of Zuñi Culture Growth," Fourth Report of the Bureau of Ethnology, (1882–83), Govt. Printing Office, Washington, D. C., (1886), p. 476.

[42] H. H. Bancroft, *op. cit.*, p. 102.

tinctive in their structure. The blocks of snow were arranged in spiral courses which produced a hemispherical effect. Boas gives a sketch of the ground plan of a snow house found on Davis Strait, which shows a small dome and a small elliptical vault as an entrance to the main section of the house.[43]

Mounds and Other Earthworks. Mounds have been discovered principally in the eastern section of the United States. Most of the burial mounds were conical with a circular or oval base. The typical pyramidal mound was a truncated quadrangular pyramid, but a few irregular pentagular ones have been found. The diameters of the bases of the conical mounds varied from six feet to three hundred feet, and the pyramidal mounds were usually larger. The largest mound of the entire section, located in Illinois, was one of the pyramidal type one hundred feet high with a base covering about seven hundred square feet.[44]

One group of earthworks in Ohio consisted of circles, squares, and octagons. The circles were quite unusual in their close resemblance to true circles and the octagon, while not a regular polygon, was a symmetric eight-sided figure with remarkable approximations to the properties of regularity. The sides of the square were 928, 926, 939, and 951 feet in length and the greatest variation of the angles from a true right angle was fifty-seven minutes. McGee and Thomas think that it is improbable that such accuracy could have been attained even by a well-trained eye and that the Indians must have had some method of drawing one line perpendicular to another.[45] Brownell states that two earthen inclosures were found at Circleville, Ohio, of which one was an exact circle and the other an accurate square whose corners corresponded to the cardinal points of the compass.[46] The town itself seems to have been built in the shape of a circle and it is from this fact that it derives its name.

Ornamentation. East of the coast mountains and south of Vancouver Island the majority of the ornamental designs were distinctly geometric in form. The technique of right angle and radiate weaving in basketry tended to produce various geometric patterns. Quite frequently the pottery designs were borrowed from the textile arts and basketry. A rather interesting principle found in weaving was that no line could intersect itself,

[43] Franz Boas, "The Central Eskomo," Sixth Report of the Bureau of Ethnology, (1884–85), Government Printing Office, Washington, D. C., (1888), pp. 541–542.

[44] W. J. McGee and Cyrus Thomas, *op. cit.*, p. 307.

[45] *Ibid.*, pp. 373–377.

[46] C. D. Brownell, *The Indian Races of America*, Dayton and Wentworth, Boston, (1855), p. 41.

which idea was carried over into pottery decoration and it is said that nowhere in native American art have loops in the curved forms or intersections in the angular forms been found.[47] In the development of designs rectangular figures are regarded as preceding the circular ones.[48] In the Navajo blanket designs all figures consisted of straight lines and angles, and Reagan lists the following patterns as those found on Navajo pottery: opposed sets of isosceles triangles, line bordering dots, hooked spirals, double spirals, vertical and horizontal lines, and stepped figures.[49]

The Sioux separated designs into their structural elements and named them accordingly. Some of these divisions as listed by Parker are:

(1) Rectangles in a stepped position,
(2) A cross with two bars,
(3) Two opposite rows of right-angled triangles,
(4) Parallel lines,
(5) Inverted equilateral triangles,
(6) Long triangles standing upon others of equal size,
(7) Lozenges,
(8) A stepped pyramid,
(9) Parallel lines with small squares between,
(10) A rectangle divided into nine rectangles of contrasting colors.[50]

The patterns used by the eastern Indians consisted chiefly of circles, opposed curves, parallel lines, dots and dashes. The Indians of the Mississippi Valley made little progress in the textile arts and their designs were, to a great extent, curvilinear. Their motifs included meanders, scrolls, circles, and various combinations of curved lines. The principle rectilinear figures were lozenges, zigzags, and checkers.[51] One of the designs on pottery from Florida consisted of semicircles of six concentric circles separated at regular distances by five parallel lines.[52]

Other interesting applications of geometric figures in artistic design are: the use of the trapezoid by the Apache, the hexagon

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[47] W. H. Holmes, "Pottery of the Ancient Pueblos," Fourth Report of the Bureau of Ethnology; (1882–83) Government Printing Office, Washington, D. C. (1886), p. 359.

[48] J. W. Fewkes, "Archeological Expedition to Arizona in 1895," Seventeenth Report of the Bureau of American Ethnology, (1895–96), Part II, Government Printing Office, Washington, D. C., (1898), p. 702.

[49] A. B. Reagan, "Some Notes on the Archaeology of the Navajo Country," *El Palacio*, Vol. XXIV, (1928), pp. 339–342.

[50] A. C. Parker, *op. cit.*, p. 95.

[51] W. H. Holmes, "Ancient Pottery of the Mississippi Valley," Fourth Report of the Bureau of Ethnology, (1882–83), Government Printing Office, Washington, D. C., (1886) pp. 374–5.

[52] H. R. Schoolcraft, *op. cit.*, Vol. III, p. 80.

by the Mojave, and the combinations of lines, points, lozenges, and circles in the carvings of the Eskimo.

The Indian people as a race generally attached great importance to the practice of ornamenting the body. One such form of personal ornamentation was that of tattooing which was indulged in more extensively among the tribes of the west. Some designs were totemic while others were merely simple combinations of dots and lines. The California women tattooed their chins in three blue perpendicular lines drawn downward from the center and corners of the mouth; the Mojaves used similar vertical lines but drew them closer together.[53] Among certain groups of Eskimos the manner of tattooing was dictated by social rank; a plebeian woman had one vertical line in the center of her chin and one parallel to it on each side, while a woman of the nobility had two vertical lines from each corner of her mouth.[54] The Kiowa women frequently had small circles tattooed on their foreheads.

Paint was also used for personal ornamentation, especially during ceremonies. One of the favorite designs used in the dances of the Central Californians was made up of broad stripes painted up and down, across, or spirally around the body.[55] In the Sun Dance of the Teton Sioux the Chief Dancer was painted with a black semicircle from the forehead down each cheek, others at his shoulder joints, and complete circles about his elbows and wrists. In a ceremony of the Arikara medicine-men the leader painted a black circle around his face and others about his wrists and ankles.[56]

Many other instances of the use of geometric figures in artistic design and ornamentation may be found in the legends of Indian lore. In most cases the basic configuration was quite simple though the resultant design was rather intricate. The variations of form ranged from the simple combinations of point and line used in carving and tattooing to the spiral of the Eskimo hut and the truncated cone found among the hat designs of the Tlingit. The fact that the circle was the most popular of all geometric figures was probably due to its symmetry of form and facility of construction. It is probably the most natural of all geometric configurations.

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[53] H. H. Bancroft, *op. cit.*, Vol. I, pp. 332, 369, 480.
[54] *Ibid.*, p. 48.
[55] *Ibid.*, p. 393.
[56] E. S. Curtis, *op. cit.*, Vol. III, p. 95, and Vol. V, p. 67.

AN OLD EXPERIMENT IN NEW DRESS

By Noel C. Little
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In his *Dialogues Concerning Two New Sciences*, Galileo Galilei describes a series of experiments to test the laws of uniformly accelerated motion. A "very round" polished bronze ball is rolled down a groove cut in the edge of a two inch plank some 20 feet long. The groove is lined with parchment. Times to the accuracy of a tenth of a "pulse-beat" are compared by weighing the water which escaped from a small orifice in a large vessel. These simple experiments of three hundred years ago mark the beginning of our modern physical science.

Without changing the general scheme of these historic experiments, it is now possible, in this age of steel and electricity, to so modify them that an absolute value for the acceleration of gravity, precise to a fraction of a percent, may readily be obtained.

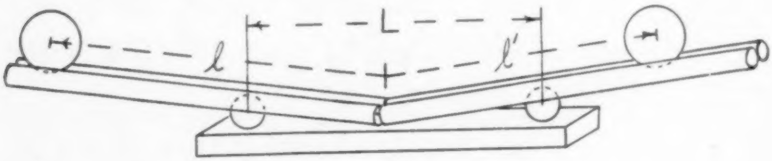
The groove is formed by clamping together two rods of steel about a meter long. These rods sell as "ground and highly polished rounds" at about ten cents a pound. Their diameter may be a centimeter or two. Thus an accurate incline is formed, the dimensions of the cross-section of which may be determined with precision by means of a micrometer caliper. Down this groove a steel ball-bearing rolls with remarkable consistency, only slightly retarded by friction. The radius on which the ball rolls depends of course upon the particular diameters of ball and rods. It is an interesting exercise in applied geometry to find the vertical distance from a horizontal axis through the center of the ball to the point of contact with the rod. This distance is the rolling radius. However, it is the ratio of the radius of gyration of the ball to this rolling radius which concerns us in correcting for the fact that our ball is not, as with free fall, acquiring only translational kinetic energy, but is experiencing a change in angular momentum as well. To find what acceleration the ball would have had if it slipped freely down the incline without rolling, one multiplies the observed acceleration by one plus the square of the above mentioned ratio. Denoting this correction factor by A, the relation

$$A = 1.4 + \frac{0.4x^2}{1 + 2x},$$

where x is the ratio of diameter of rod to diameter of ball, is readily obtained. For the simple case where ball and rod are of the same diameter A becomes 1.533. A very good design is for an inch ball-bearing to roll down half inch rods. Then $A=1.45$. In any case, A may be determined with high precision for both rods and ball bearings are accurate to size by plus or minus half a mil.

We are interested in determining the acceleration during free vertical fall, yet we measure only the component of that acceleration along the incline. Thus the observed acceleration along the rods must be multiplied by a second correction factor, B, which is the ratio of the length to the height of the incline.

The measurement of the length presents no difficulty. The height, however, should be small in order that the ball shall not roll too fast, and therefore must be measured to a fraction of a millimeter. Further, the ordinary table top is not sufficiently level to act as a basis of measurement.



To solve this difficulty a double incline is used. Two pairs of groove-forming rods are placed end to end on top of a flat piece of steel making a large mouthed "V." The arms of the "V" must make equal angles with the flat. To test this adjustment and to measure the angle of the incline, a ball bearing is pushed in lightly underneath each incline until it just comes in contact with both rods and the flat. A meter stick is now laid alongside these balls and the distance between them measured. The point of contact of meter stick and ball may be accurately determined, for the polished ball, acting like a convex mirror, images the parallel millimeter marks on the meter stick as a group of radial lines. The particular mark which is not turned upon reflection is the one to be read. If each pair of rods makes the same angle with the flat this distance is bisected by the apex of the "V." Again, it is an interesting exercise in applied geometry to derive the relation which our correction ratio, B, bears to this distance L between the balls, their diameter, D, and the ratio, x, of diameter of rods to diameter of ball. A formula sufficiently accurate for the small inclines we shall use is

$$B = \frac{L}{D(1 - x + \sqrt{1 + 2x})}$$

Thus in the two special cases mentioned above, for rods and balls of the same diameter $B = \dfrac{L}{1.732D}$

and for inch balls on half inch rods $B = \dfrac{L}{1.914D}$.

The adjustment of the two pairs of rods to equal angles of inclination with the steel flat does not guarantee that the two are inclined equally to the horizontal. The flat itself may not be level. It is, therefore, necessary to put wedges of paper or cardboard under one end until it lies in the true horizontal plane. A spirit level may be used for this adjustment, but the following method gives us data which we shall use in computing a third correction, necessary on account of friction.

Place a ball at the top of one incline, say the left hand one, allow it to roll down its length, l, and then up the opposite side as far as it will go. Note this distance, l', which the ball ascends. Now if the flat is truly level, when the ball is started at the top of the right hand incline and allowed to roll down its length, l, it should ascend the left hand incline the same length, l'.

We now turn to the theory of the correction for friction. Obviously $l > l'$. The ball does not ascend quite to the height from which it started. Potential energy is converted into heat by friction. Let us, however, think of the friction as a force which produces an acceleration a', opposing that due to gravity as the ball gains speed as it rolls down an incline, and aiding that due to gravity as the ball loses speed as it ascends an incline. If v is the speed of the ball at the apex of the "V" we may apply the well-known equation

$$v^2 = 2as,$$

to either speed gained in coming down or lost in going up. Hence

$$v^2 = 2(a - a')l = 2(a + a')l'$$

From which

$$\frac{a'}{a} = \frac{l - l'}{l + l'}.$$

Thus from the measurements of two lengths, we obtain the ratio of the acceleration due to friction to the acceleration if the ball

had been unimpeded. We shall see shortly that we need correct our observed acceleration by only three fourths of the square of this ratio. Thus, the third factor, C, by which we must multiply the observed acceleration to obtain the correct value of g is given by

$$C = 1 + \frac{3}{4}\left(\frac{a'}{a}\right)^2.$$

In practice, the ratio a'/a is so small that this correction can almost be neglected.

At last we come to the measurement of the actual acceleration along the incline. This involves time as well as length. Times to fifth of seconds can be obtained with a stop watch. However, this age of electricity with alternating current of controlled frequency affords a simpler cheaper instrument. For want of a better name we shall call it a time-wheel. It consists of a two-watt Telechron motor giving 1 R.P.M. mounted in a wooden frame. To the axis of the motor is attached an aluminum disc about a foot in diameter. The disc is graduated into degrees. Every tenth degree is numbered consecutively from 1 to 60. A fixed pointer or wire fiducial mark is so attached to the wooden frame that the disc with its scale graduated to seconds and tenths rotates behind it. To measure a time interval one merely reads the scale behind the pointer at the start and finish of the interval and takes the difference. Experience has shown that accuracy to a tenth of a second may be realized with but slight practice.

In order to obtain as long a time interval as possible, we shall allow the ball to roll up and down the incline not once or twice but ten or a dozen times. The procedure is as follows. Starting the ball at the top of one incline, read the time-wheel as the ball clicks on passing over the apex of the "V." Note and read the successive distances to which the ball ascends on both sides. When these excursions are reduced to 10 or 20 cm., again read the time-wheel as the ball clicks on passing through the center. The linear acceleration is eight times the square of the sum of the square roots of these successive excursions divided by the square of the elapsed time. This acceleration multiplied by the three correction factors, A, B, C, yield g correct to a fraction of a percent.

The formula for the acceleration, just expressed in words, follows at once from the application of the well known formula

$$s = \tfrac{1}{2}at^2,$$

if we remember that as the ball rolls up the plane the acceleration is $(a+a')$ but when it rolls down it is $(a-a')$. Thus the time up and down an excursion of length, l, is given by

$$t = \sqrt{\frac{2l}{a+a'}} + \sqrt{\frac{2l}{a-a'}}\,.$$

In observing a series of excursions it is only the l's which change. Thus in finding a formula for the total elapsed time, it is only the square roots of the l's which must be summed. When such a formula is obtained, terms containing the ratio of a'/a will be found. These, expanded by the binomial theorem, give rise to the correction factor C mentioned above.

The data taken from two runs are here given as evidence of the precision which may be obtained.

Diameter of ball bearing = 1.000 inch
Diameter of rods = .622 inch
Distance between balls = 93.5 centimeters

$A = 1.469$ $B = 19.65$ $C = 1.0032$

	Sum of Square roots of excursions	Elapsed time	Acceleration of gravity
1st trial	87.2	42.3	983 cm./sec.^{2}
2nd trial	87.1	42.4	978 cm./sec.^{2}

A numerical value for the acceleration of a freely falling body is conspicuous in "Two New Sciences" by its absence. Nowhere does one find a value of g in cubits per pulse-beat per pulse-beat. The reason is not far to seek. Galileo had no knowledge of the methods of integration which gives us the radius of gyration. He could not correct for the rolling. Unfortunately the elementary student is not much better off than Galileo. Nevertheless, even if he must accept as given the correction for rolling, by performing this exercise he will learn to appreciate the advantages of modern methods and obtain a greater respect for the exactness of laws governing uniformly accelerated motion.

The Significance of the Home.—The unit of American life is the family and the home. It vibrates through every hope of the future. It is the economic unit as well as the moral and spiritual unit. But it is more than this. It is the beginning of selfgovernment. It is the throne of our highest ideals. It is the source of the spiritual energy of our people.—HERBERT HOOVER.

SOME TECHNIQUES IN MAP STUDY

By Anne M. Goebel
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It is the purpose of this article to apply to the teaching of geography the general learning processes and techniques with which map study is concerned. The analysis of the activity on the part of the learner in mastering geographic skills as well as the activity on the part of the teacher in leading pupils at various levels to such mastery is considered.

The function of a map is to give an idea of relative location and areal distribution. An understanding of this distinctive function is concerned with the relationship of cultural to natural items. The habit of looking on maps for the outstanding facts about the human items of a region and of relating them to the natural should be encouraged. In visualizing each region studied many types of ideas may be gained through the use of maps, therefore they tell an interesting story to pupils trained in their use. Since maps hold a fascination for those knowing how to use them, the teacher needs to be at home with maps. In order to appreciate them as a valuable tool, he should be map minded and attempt to establish the trait in his pupils.

Gradual cumulative map reading ability, a process akin to reading the printed page, is essential in the solving of geographic problems. Encouragement of the atlas habit and the sending of pupils to maps for items lending specific color to their geographic knowledge, is vital. Map exercises make a very definite contribution to a given unit of subject matter. When they are presented at the beginning of a unit, pupils should be lead to read them, discovering for themselves facts and possible geographic relationships before they are sent to the other sources of information.

Pupils should be lead to combine symbols for cultural items with those for the natural features and conditions in explaining the probable adjustments in a given area. When the need for a new map idea arises, time should be given for its introduction. A basic principle to bear in mind is that the idea precedes the symbol. Teachers should omit the use of detailed mapping ideas while working for power in the pupils to make and interpret maps naturally as the need arises. The translation of map reading into map imagery is the fundamental requisite upon which the technique of map reading hinges.

The specific map abilities needed by pupils at a given level in order to read from maps the necessary core understanding are worthy of consideration. In assigning various abilities at different levels the critical problem is not to determine the most difficult idea of this sort which a child can master at a given level in his training, but to determine the type of map ideas needed in developing geographic understandings which constitute the major content goal at a given level. The goal for map study should be established at the outset and recalled repeatedly until it is realized. It is well to develop and use map concepts early, however on entering the fourth grade pupils have had but few exercises dealing with maps. By the end of the fourth grade the geographic understandings of the eight or ten units studied are tied to the one idea—distance from the equator. This warp thread has been picked up repeatedly since man's activities are explained in part by the distance of his home from the equator. Pupils readily understand that life differs between the equator and the poles and very soon they place in about the same category those countries having the same latitude.

Fourth grade pupils have recognized not only the equator but also the tropics and circles, not as latitude lines but as functioning direction guides. They know the relative location of the countries studied and the approximate distance of any place on the earth's surface from any other place without the use of a scale. The fourth grade pupil is expected to read from maps the location of places from the equator, not in terms of degrees of latitude but in such phrases as "far from," "near," "half-way between the equator and the pole," etc.

Pupils have recognized that between the tropics the sun is never very low. They know that the farther from the equator one travels the lower and lower the sun is in the sky and that the length of the days varies in direct proportion to the distance. Pupils have developed the idea of decrease of temperature with increase of distance from the equator. They should be familiar with the fact that great distance from the equator means shorter summers and longer winters; hence the wearing of warm clothing for a longer season and light clothing for a shorter season.

Pupils very early are capable of reading ideas from maps having pictorial quality. New features should be represented on the most simple type of map possible, then gradual transition made from the concrete to less symbolic representation. Pupils need

clear concepts in order to get definite understandings. Since they are not yet ready to use complex maps, going slowly at first and giving accurate understandings may mean later momentum.

Fourth grade pupils are capable of recognizing on a hypothetical, uncaptioned map the symbol for land, water, mountain, strait, peninsula, island, delta, lake, river, source, mouth, etc. They are not expected to read into maps very much about the natural conditions. A fourth grade pupil should recognize the cultural sign for a city, railway or a canal. In reading the sign for a city at this level pupils should not be held responsible for explaining in detail its location on a highly generalized map. They should be able to explain why it is easier to travel in one region than in another by recognizing the symbol for heighth of the land, slope, etc. Obviously, at this stage of training, no quantitative facts and no distribution aspects of the personality of the region are expressed.

At the end of the fourth grade the first group of understandings is transferred to the fifth grade where in the first half there is rapid gain in map reading ability. Pupils cannot yet read all relationships but they have a general idea of land and water distribution and they have the ability to fit their partial map network into that of the land and water pattern of the world.

Being at home with maps involves the two fold activity of expression and interpretation. Relatively little time, in the average school has been given to map expression. Work of this type has rested very largely with the individual teacher. If by chance, a group of children was under the direction of a teacher whose hobby was map making the results were quite different from those of a group whose teacher had no particular interest in the activity. Simple informal maps should be made occasionally by all pupils. Such exercises are an easy way of presenting ideas. They should provide a means of building concepts of making clear cut images, and of recording and presenting findings. Followed by careful interpretation they contribute to the solution of the problem at hand.

The ability to select for spontaneous expression ideas which can best be expressed in map language is as essential as is the selection of symbols best suited for recording such ideas. Many pupils enjoy writing ideas in map language. They should realize that maps are not made for the sake of the map alone but for the presentation of findings not pictured in the desired form.

After seeing several maps children are ready to try making one of their own. Suggest to them that they are going to make a picture of the area. Pupils should know the pattern of the countries studied. Since they have a variety of interests allow them to work out their own ideas for expression. Later in interpreting the results the teacher may have to ask, "What does this represent?" or "Why did you use this symbol?"

By the time the pupils have reached the sixth grade they have a realization of the special value of maps in expressing ideas. They are capable of showing the distribution of people and the amounts of production. It may be necessary in the beginning, to aid in determining the unit for expression or the scale by which the area mapped is pictured. Pupils should convert trade statistics into readable form on an outline map, read the distribution, and raise questions concerning the reasons for the distribution shown. A primary issue is that of sustaining the effort until the problem at hand is solved.

The characteristics of an ice scoured plain might well be placed on an outline map and followed by the questions, "What did the glacier do?" "Why would you expect to find hills and lakes in the area?" "Where would be a good place for a farm?" "Why should there be a rich soil pocket in such a place?"

After the study of specific items on a topographic map, it is well to mold in the sandpan that which was discovered. Use pieces of cardboard of different lengths and widths in showing contours. Close arrangement of the strips across the pan represents contours showing a steep slope. There is but slight change in altitude when the strips are far apart. The cardboard may also be rolled and placed in the pan, the widest or highest in the center. Such strips, farther apart on one side, show the gradual slope of a mountain most likely to be climbed.

Map reading is relatively more essential than map making, however both ideas need to be embodied into the exercises of a given unit. Skill in map interpretation involves the presentation of simple maps at levels where they are understood—where the information functions in explaining human activities. It involves an understanding of the specific function of a map as that of giving information of human and natural items in various sections of the world. The exercises that follow are not exhaustive. They simply suggest ideas for map reading and map making that might well be incorporated into the geography units of a course of study.

1. In planning an overland trip to Los Angeles, California, to attend the Olympics, present a road map. Pupils should be capable of reading from such a map the direction of the highway, the type of pavement, the states crossed and the cities visited. After the study of a physical map of the Western States, they should be able to give something of the ways in which man is occupied along this route.

2. On presenting a map of the gulf coast of the United States, inquire, "What might the people living in this section be doing to make a living? Why would plantation agriculture be important? Are the streams an indication of heavy rainfall? Does the rainfall lead one to believe that there are forests? Are the forests a sign of fertility? What other natural items are necessary for the growing of cotton? How long is the growing season in the South?" In verifying answers turn to isotherm maps.

3. "This map of Norway shows a very irregular coastline. What does such a coastline indicate? Is fishing likely to be the only industry along the coast? In what way are good harbors an indication of trade?" If pupils are unable to answer send them to the text and to other sources of information.

4. Present a map of Switzerland with the comment, "Geographic relationships are here clearly shown. Why were Geneva, Lucerne and certain other cities located where they are? What other natural items help to explain their location? In what way do the steep slopes to the east suggest difficult transport?"

5. "The aeroplane view of this city shows a gridiron street pattern. Is this an indication of level land? Why? What city might this be? How are the people fitting their lives into this area?"

6. After the consideration of a map showing the distribution of wheat in the United States, ask, "What outstanding things are shown about the distribution? What questions does this raise? What is the rainfall in these sections? How much rainfall is necessary for the growing of wheat? In what way does the direction of the mountains influence production? Nearness to the ocean?"

7. Set up a bird's eye view of Colorado by presenting a physical map at the beginning of the period. Ask the pupils what they might see from a car window in passing through the state.

8. Motivate the study of the Amazon through reference to it as another Congo. Recall the human activities in the latter area. Note the nearness to the equator as well as the heavy precipitation. Give further imagery through picture study and through the reading of supplementary material.

9. In making an initial survey of Australia present a population distribution map. "Why is the greatest density in the southeastern part? Does the location of the country have anything to do with the population distribution? Where in low latitude countries do most of the white people live? Does the rainfall map help in explaining the distribution of population? There are additional factors which help in explaining the density of population in Australia. Find them in your reading exercises."

10. "On the map of England count the number of cities having more than one hundred thousand people. How do you account for so many in so small a country? How many of these cities are built on coal? Is this true in other manufacturing areas? Compare it with the northeastern part of the United States."

11. "What facts do you read from this map of Argentina showing the distribution of wheat? In what way are they related to the natural items? What is the latitude of this country? Compare it with that of the United States. About what would the average July temperatures be? January? At what time of year does this harvest season come? What is the average rainfall of Argentina?

12. Present a simple map of the Nile which the pupils are likely to image correctly. Ask about the industries that might be carried on along the river. Tell the pupils that there are some new symbols shown in the legend of the map. Expect the pupils to note the cataracts and consider their influence on shipping.

13. In attempting to give a regional picture of Russia present a physical map of the country. In discovering that the latitude is similar to that of the United States, pupils will expect the products also to be the same. The growing of cereals is related to the cold winters, the hot summers, the moderate rainfall and the great plains of Russia. Pupils will read from the map few large cities and an open spaced railroad net. They will note that the general location for trade is not so favorable as is the location of western European countries. They will further see that the plains are fairly well supplied with rivers, however, those to the north are frozen a part of the year while those to the south flow into more or less land locked seas. Correlate this map study with picture study, tying tillage again and again to the favorable natural conditions.

14. On a topographic sheet of Kansas mark the outstanding items *A*, *B*, *C*, *D*, etc. Ask "What feature is shown at *A*? Which letter marks the highest peak? the lowest valley? etc."

15. Combine map study with field work. If direct observation is impossible, the utilization of pictures should be encouraged. Before going into the field it is well to study maps. Carefully reading from topographic maps the elevation and slope should give a concept of the land forms. Ask: "What would you expect here? What about the young valley to the north? What does the map tell about the slope?" Before starting on field work appoint a meeting place in the field, for discussion. Note the ability of members of the group to recognize the place. In considering the landscape ask, "What do you see that was not mapped? Map the utilization of the slope bringing in the several cultural items shown."

16. Consider the uneven distribution of population in Italy. Attempt to account for the density at the lowland fringe as well as for the open center. "What does the physical map tell about this area? Compare the population of Italy with that of other densely populated countries considering the work pattern of the country. In other countries where there was a dense population what was the most important kind of work? Does manufacturing help to explain the presence of many people along the Mediterranean coast of Italy? Do the production maps suggest that specialized agriculture is an outstanding kind of work? If not, what is your conclusion concerning the ways in which many of these people in Italy make their living?"

17. Test for the identification of the silk trade of Japan by setting up the distribution of several textiles and asking for their recognition. It may be necessary to say, "Trade in this product is highly concentrated. It is carried chiefly to Western Europe and to the United States in high-grade

ships. Partly because of its great value it is transported as far as possible by train. Why is this expensive type of carriage utilized? Is the trade thus distributed and ranked in cotton, silk, or wool?" Once pupils have recognized the map distribution and described the conduct, follow by graphing the importing and exporting countries.

18. Ask for a statement setting up the personality of wheat production. Compare rank of producing countries and transcribe the data on an outline map of the world.

19. About a year after the introduction of the term "latitude" or when the idea is thoroughly assimilated, begin teaching the meaning of longitude. This is easily done in connection with current events. If a gong is sounded at nine in Emporia what time would it be in Los Angeles? Tokio? Paris? The Armistice was signed at six o'clock in the morning in France. At what hour was that in New York? Chicago? Honolulu? Bombay? London? Study of a world map should aid in answering these problems.

20. In the early stages by map interpretation pupils should read from a simple hypothetical map net. When such a map is placed before them it is a matter of interpreting rather than of remembering. Check statements of the following nature with a plus or a minus: *A* is on land; *B* is on water; if you threw something in the stream at *C* it would float downstream to *D;* the distance from *A* to *F* is greater than from *A* to *B*, etc.

21. Encourage reading area and direction from simple map nets. These maps might well be of regions both north and south of the equator. The parallel lines should vary in distance. For example, some should be ten degrees apart and others only five. Check with a plus or a minus the following statements: the island shown in Figure A is north of the equator and that in B is south; the island shown in Figure C is ten degrees south latitude and that in B twenty-degrees north; in Figure A the June days are longer than the December; on network B the sun is always high in the sky, etc.

22. On a single map network use both parallel and meridian lines. Place letters of the alphabet at several points where these lines come together. Ask for reaction to true and false statements: the distance in miles between *A* and *D* is equal to that between *C* and *F*; the distance is less or greater than that between *C* and *E;* the picture taken as *F* might show men harvesting corn; at *E* a forest scene would show coniferous trees.

23. Places in the following exercises are well scattered over both hemispheres. Check with a plus or a minus the following exercises having to do with relative size and direction of areas shown on a mercator, a conical and a polar projection: the area on the first network is larger than that on the second; at *A* on Figure two the sun would be seen in the southern sky; at *F* the growing season is very short, etc.

24. An aeroplane made a forced landing at fifty-seven and a half degrees north latitude. In what country might this have been? Why was it an unusually inconvenient place for such an accident? Careful map study may be necessary in explaining the reasons for the answer.

25. Find Seattle, Washington and Zurich, Switzerland on the map. What is their latitude? Does this mean that people very likely will be doing the same thing? Why not?

26. Locate three places having latitudes of about thirty, forty and fifty

degrees. Tell about the differences in activities at these places. In what way can you tie farming to each of these sections? Lumbering?

It is of fundamental importance that the limitations of maps as sources of information, be recognized. It is disastrous to attempt to base all findings on map work when their contribution needs to integrate with that of pictures and other concrete material in visualizing the printed page. Get what maps have to give, then go to other sources for additional geographic information. Mere location of a place is a by product of map study. There should be a functioning concept—a picture of the area in its true form. The residue that pupils carry away from map study should be a definite understanding of the major types of adjustments to the natural environment.

NEW JERSEY SCIENCE TEACHERS ASSOCIATION

The New Jersey Science Teachers Association met at State Teachers College, Montclair, February 18 under the leadership of the president of the Association, Mr. Vernon L. Frazee. The program included the following numbers:

MORNING SESSION

"Greetings to the Science Teachers of New Jersey," President Harry A. Sprague, New Jersey State Teachers College at Montclair.

"Recent Discoveries in the Physical Sciences," Dr. Henry A. Barton, Director, The American Institute of Physics.

"In the Name of Science," Paul R. Mann, Evander Childs High School, New York City.

Demonstrations of Experiments of Interest to Teachers of High School Science.

A. Experiments in Chemistry, Dr. Rufus D. Reed, Visiting Teachers, and Students. For this part of the program a series of experiments of interest to teachers of chemistry was demonstrated informally. Most of the experiments were selected because of the simple apparatus used. The following were some of the experiments shown: (1) Simplified photographic apparatus for preparing slides or visual demonstrations of crystals, textiles, etc.; (2) A series of experiments for the analysis of gasoline.

B. Experiments in Physics, Dr..Robert W. McLachlan, Visiting Teachers and Students. The experiments in this division were selected mainly from the fields of radio, light, and the structure of matter.

C. Experiments in Biology, Dr. Charles E. Hadley, Visiting Teachers, and Students. The demonstrations in biology were selected to show a wide range of experiments that are useful in high school instruction. In addition, there was a demonstration of the techniques for making microscopic slides.

AFTERNOON SESSION

"Talking Motion Pictures in Teaching Science," Dr. M. R. Brodshaug, Erpi Picture Consultants.

Part I. Selections from the University of Chicago Physical Science Series: (A) Oxidation and Reduction; (B) The Molecular Theory of Matter.

Part II. Selections from Erpi Talking Pictures: (A) Flowers at Work; (B) Tiny Water Animals; (C) Seed Dispersal.

SCIENCE VOCABULARY IN ADVERTISEMENTS—A PUPIL PROJECT

By Victor C. Smith
Ramsey Junior High School, Minneapolis, Minn.

At the end of the year of general science a group of ninth grade pupils* made a survey of the advertisements of eight current magazines. The object of the project was motivation of review of the science vocabulary, and "to see if general science was any good" by checking their knowledge against use of scientific knowledge.

The magazines surveyed were three copies of *The Saturday Evening Post*, two copies of *Literary Digest*, and one each of *Good Housekeeping*, *Woman's Home Companion*, and *Ladies' Home Journal*.

The technique of surveying the advertisements was: one pupil went through each magazine, numbering the "ads" and underlining the words which in his judgment were connected with science. After the magazine had been checked by another pupil the words were listed alphabetically with frequency tabulated. This list was submitted to a committee which decided what words to include and which made the master list. The committee also checked some of the magazines.

These judges acted, apparently, upon the assumption that if a word had acquired meaning for them through the study of general science that it was related to science. Consequently adult judges would probably select a smaller number of words, due to the wider range of adult information. These judges, however, are very superior in mental ability, according to Terman's use of the term. Lack of training in research technique undoubtedly leaves the ninth graders somewhat handicapped in attaining complete accuracy. They enjoyed the project, and did not think it especially difficult.

Six hundred forty-two "ads" were covered, of which four hundred ninety or seventy-six per cent contained words associated with science. Fifty-six or nine per cent used illustrations similar to those used in general science books.

This study is somewhat comparable to one reported by H. K. Rhodes in School Science and Mathematics, vol. 19, pages

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* Wallace Knutson, Jane Harding, Barbara Bruntlett, Robert Adams, Leonard Ring, Jenevieve Ford, Jack McGrew, Frances O'Shea, Katherine Bruntlett, Donald Eastman and James Nelson, all of Ramsey Junior High School, Minneapolis.

A list of words found eight or more times follows:

vitamins	61
soap	53
electrical	53
scientific	52
color	45
gasoline	45
engine	36
water	36
naphtha	34
oil	32
antiseptic	31
element	28
health	27
skin	24
germ	24
energy	23
minerals	23
motor	23
pores	23
acid	22
chemical	22
food	22
spark plug	22
tissues	20
metal	19
automatic	19
free wheeling	19
ingredients	19
disease	18
heat	18
floating power	18
sleep	18
power	18
telephone	17
tubes	17
iron	17
radio	17
photograph	17
ultra-violet	16
film	16
lubrication	16
dirt	15
physician	15
stimulate	15
odor	14
tests	14
enamel	14
resistance	14
air	14
piston	14
cylinder	13
salts	13
fabrics	13
sun	13
hydraulic	13
laboratory	13
cellulose	12
carbon	12
texture	12
infection	12
nature	12
sterilize	12
pyorrhea	12
digestion	11
combustion	11
blood	11
refrigerator	11
spark	11
aluminum	10
alkali	10
bones	10
breath	10
chlorine	10
diluted	10
gear	10
light	10
pressure	10
rayon	10
transparent (cy)	10
boil	9
caffein	9
digest	9
horse power	9
intestinal	9
laxative	9
machine	9
sunshine	9
circulation	8
clutch	8
constipation	8
diet	8
dynamic	8
irritate	8
nourishment	8
smoke (not tobacco)	8
tuning	8

458–460, in 1919. Rhodes found fifty-eight technical terms in thirty" ads" in three magazines. The present study is not limited to technical terms.

An examination of the list of words found indicates that the average advertiser expects his reader to understand words used in general science. Scientific terms are used very rarely to impress the reader—that is, the aim seems to be to inform rather than mislead the reader by use of words he cannot understand.

Of the list given above, the vocabulary relating to health and hygiene contributes thirty-three words, physics thirty-three, chemistry eighteen, and no other group contributes as many as five.

It may be objected that these words are not scientific. Many if not most of them are used in general science books. They are sufficiently difficult that they could be used as a test with the preliminary instructions, "Define these words from the standpoint of science." Ten intelligent judges consider them to be scientific in the setting from which they were selected.

Many of the less frequent words are more technical than these given, as volatile, Tyrannosaurus, calcium chloride, cadmium, synchro-mesh, polyneuritis.

It may be concluded that the study showed that general science does have practical value in training pupils to read advertisements with adequate understanding of the terms used.

ENAMELED METAL BLACKBOARDS DEVELOPED FOR SCHOOL USE

Sheet metal blackboards, with a vitreous porcelain enamel surface, may replace slate in schoolrooms, with the invention of a metal blackboard declared to be one of the most practical innovations since slate boards were adopted in 1863.

Substitutes for slate board have been sought for years. Etched glass, fiber board, composition board and painted wood have been among substitutes suggested. The steel blackboard was conceived by R. S. Conrow, Middletown, Ohio, and perfected for commercial production in the laboratories of a school equipment concern at Grand Rapids, Mich.

Vitreous enamel is applied to ingot iron sheets in manufacture and an acid bath used to remove the sheen of the enamel. The paint is applied under vibration to insure a smooth surface. A method of joining panels together with a flat joint through interlocking fingers on the back, and a way of firing a curvature into the board so that it will cling to a wall surface have been worked out.

In laboratory tests, 24,000 chalk marks and erasures were made on one spot in the metal blackboard, without hurting the surface. The same test wore a hole in slate an eighth of an inch deep. The metal blackboard is said to weight half that of slate, to have a permanent color, not to be affected with cleansing fluids, and to be rustproof.—*Science Service.*

RELEARNING FRACTIONS

BY MYRTIE COLLIER
University of Southern California
University College, Los Angeles

The subject of fractions is, perhaps, the one most needing reform in the beginning work of arithmetic. As presented in most text books fractions are dealt with in a purely mechanical fashion, such that the child is seldom *fractioning*, but is merely manipulating digits according to some given rule which is in no sense understandable to him. The writer has visited many classes where the pupils had finished the subject of addition and subtraction of fractions, and has asked the question: "Which is the greater, one-third or one-half?" No one would know, but all would instantly fall to work with pencil and paper to determine the answer by a long process of reduction.

There are only a few fractions a knowledge of which is necessary in the every-day affairs of life. These few should be *learned*, together with the necessary combinations, in the same manner in which the natural numbers are learned. Our system of weights and measures, especially the few denominations now in use, justify the following fractions only: halves, thirds, fourths, fifths, tenths, with possibly twelfths and sixteenths. Furthermore, due to our system of standard measures the *necessary* combinations in addition and subtraction of fractions are greatly limited. What excuse has one to add thirds and fifths, for example, other than solely as a class-room exercise? President Lowell of Harvard University is quoted as having said: "In the secondary schools we study what should have been finished earlier; in college we do what should have been done at school; in the graduate schools we work in a way that belongs to the college." The first phase of this criticism is exactly the point we are trying to make with regard to the subject of fractions in the elementary schools. Eliminate this useless material from the curriculum and make way for those things which "should have been finished earlier." Such an elimination would result, in reality, in an adjustment by placing much of the work in fractions as now presented in fifth-grade arithmetic, in beginning algebra where it rightly belongs.

In 1922, I carried out an experiment in the learning of fractions with a small class in the fifth grade of the Training School of the University of California at Los Angeles. The results of

this experiment were published in SCHOOL SCIENCE AND MATHEMATICS of that year.

For some time I have been anxious to test the advisability of "relearning fractions" with the upper grades or beginning high school pupils. An opportunity to try out the experiment was recently presented in a graduate course in the Teaching of Mathematics which I was offering at the University of Southern California University College. My class was composed almost entirely of high school and junior high school teachers from Los Angeles and neighboring cities. Other members of the class were preparing for the junior college credentials. All were well prepared in the subject-matter of mathematics, most of them having majored in mathematics in various universities throughout the United States, some having studied under distinguished professors of mathematics. Taken all in all, this was one of the most enthusiastic and progressive classes which it has been my privilege to instruct. All agreed that a clear understanding of subject-matter is the first prerequisite of successful teaching, but that an understanding of the child and his problems with regard to the subject-matter can in no sense be considered as of secondary importance. After the first few lectures my students were asking me to visit their classes that I might aid them, if possible, with their individual problems in teaching, or that we might find some opportunity for special assignment of work.

My first observation on visiting high-school pupils who were having difficulty with fractions was that such pupils were limited in their concept of commensurability. To them the term applied only to certain natural numbers. In order to extend this concept so as to include the fraction it was suggested that the standard measure of length, doubtless known by all, be utilized to introduce the idea of aliquot part.

Suppose we measure the segment PQ by the unit AB as in Figure 1:

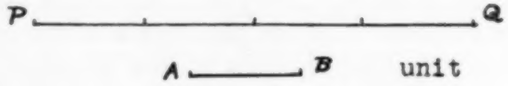

FIG. 1.

and find that the segment PQ contains the unit AB exactly four times. We may then say that AB is an aliquot part of PQ. Furthermore, as with the natural numbers, we may associate with

this idea of *length* through measurement, the idea of number and may now choose a unit AB which is not contained an exact number of times in the segment PQ, but such that this segment may still be *commensurable* with the unit AB by containing an *aliquot part* of AB, as in Figure 2:

FIG. 2.

where by breaking the unit into three equal parts and calling each "one-third" we find that the segment PQ contains one of these parts exactly 7 times and may say that the length of PQ is equal to seven-thirds of the unit, which we write as:

$$\frac{7}{3} \text{ or } 7/3$$

Or we may divide 5 inches by 1 foot by breaking the unit into 12 equal parts and calling each "one-twelfth" thus obtaining the fraction 5/12 as illustrated in Figure 3:

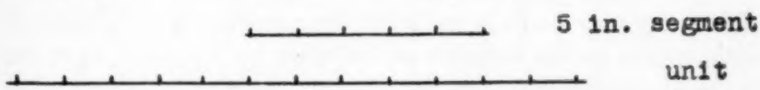

FIG. 3.

Definition: Given two integral numbers a and b, b expressing the number of parts into which the unit of length has been divided, and a the exact number of times a given segment contains one of these parts, we call the ensemble of the two numbers, written in the form a/b, read "a over b," a *fraction*, and say that the length of the given line is the fraction a/b.

From the above definition of a fraction, it follows immediately that the fraction is a *number*, and may be pictured by points on a straight line in a manner similar to the natural scale. To construct a point P to represent the fraction 2/3, for example, we may begin at the point 0 of the natural scale and lay off the *third part* of the unit *two* times to the right, as in Figure 4:

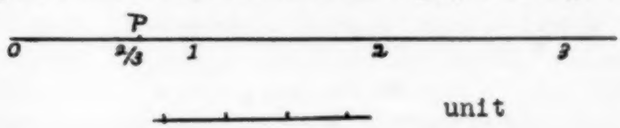

FIG. 4.

Thus given two fractions a/b and c/d, we may say that a/b is greater than c/d if the point which represents a/b on the straight line lies to the right of the point representing c/d on the same straight line.

The idea of the relation or the ratio of two magnitudes may now be established by utilizing other of the standard measures, as the comparison of 15 minutes to one hour by considering the hour as 60 minutes; the comparison of 8 ounces with 1 pound by considering the pound as broken into 16 ounces, etc. Thus in 5/12 of a foot, the unity of reference is the foot, which we divide into twelve equal parts and use one of these parts as the *direct* unit of measure; the number of these units in the quantity considered is 5; hence the ratio of the given quantity to the *unity* of reference is five-twelfths. We may now define the fraction as a *ratio*, thus:

Definition: The ratio of two magnitudes is a *fraction* whose numerator expresses the number of times the common measure is contained in the first magnitude, and whose denominator expresses the number of times the common measure is contained in the second magnitude.

We may now find any point, Q, representing the fraction a/b with respect to the numbers of the scale, by writing a as in the definition of division, namely:

$$a = b \times q + r, \; r < b,$$

where if r is zero, a/b is equivalent to the number q which measures the distance OQ. In case r is not zero, then the point Q representing a/b must lie between the two points representing the natural numbers q and $q+1$. It is by the application of this principle of representing the fraction by a point in an *ordinal* system that the learner builds up his concept of equivalent fractions.

Definition: Given two fractions a/b and c/d, we may say that $a/b \sim c/d$, read "a over b is equivalent to c over d," when $ad = cb$.

We may now consider the order of fractions by a direct comparison of symbols.

Definition: Given two fractions a/b and c/d, we say that $a/b > c/d$, read "a over b is *greater than* c over d," when $ad > cb$.

Definition: Given two fractions a/b and c/d, we say that $a/b < c/d$, read "a over b is *less than* c over d," when $ad < cb$.

We may now extend our definition of addition of fractions, namely: Given two fractions a/b and c/d we say that the sum of

a/b and c/d is the fraction $\dfrac{ad+cb}{bd}$.

Those members of the class who were to undertake the experiment familiarized themselves with the methods used in presenting the formal work in addition, subtraction and multiplication of fractions as outlined in two articles by the writer in School Science and Mathematics, referred to above.

There were 186 pupils taking both the pre-test and the final test. Following is a table of results.

Tabulation of Results

Number of Pupils	Grade	Class	Per cent Reduction in Time	Per cent Increase in Accuracy	Minutes spent in Relearning	Range of I.Q.
13	B10	Z	22+	18+	108	80–116
72	A7 & B7	Regular*	+	14+	60	Not available
22	B8	Z	3.5+	22+	75	84–108
23	A7	Z	23+	12+	90	80–102
35	A8	Regular*	16+	5+	90	96–145
21	B10	Z	9+	4+	80	66–107

* The term "Regular" is used to indicate that there was no division of pupils into x, y, and z-classes. The time of the first examination in the case of the group of 72 students was not kept in each case so that the exact per cent could not be given.

In one of the high schools represented in the experiment the principal had all the members of the mathematics department, eight in number, instructed in the new method. This instruction was given by the member of the staff who was taking my course, and who most graciously cooperated in the test reported in this article. The eight teachers tried the experiment with satisfactory results, but unfortunately their material was destroyed and thus not made available for this report.

If you have overcome your inclination and not been overcome by it, you have reason to rejoice.—Plautus.

When wealth is lost, nothing is lost; When health is lost, something is lost; When character is lost, all is lost!—*German.*

Many know how to gain a victory, but not how to use it.—*Anonymous.*

CHANGING UNFOUNDED BELIEFS—A UNIT IN BIOLOGY

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Purpose of the Experiment. This study was designed to measure the effects of specific instruction regarding certain unfounded beliefs that are associated with the subject of heredity. Heredity is one of the topics commonly included in high school biology. The items of unfounded beliefs and the usual factual items of this topic were written into a coherent presentation and used in experimental teaching.

Previous Studies. We have previously published data regarding the prevalence of certain superstitions and other unfounded beliefs,[1,2] also the results of experimentation designed to correct such beliefs.[3] It has been shown that there are certain influences which contribute to learning unfounded beliefs.[4] People in general, especially young people, often seem to believe what they are told without much consideration of whether the statements made have adequate factual foundations. The studies made show that the home, one's adult friends, and to some extent his younger friends are sources of accepted beliefs. The importance of avoiding harmful absurd or foolish beliefs need not be urged. In order that young people may not be influenced by superstitions and other unfounded beliefs, it is important that they develop ability to differentiate between unfounded assertions and factually supported conclusions. It is desirable that young persons may understand what constitutes adequate evidence or competent authority, in order that they may distinguish between facts which may be demonstrated and claims that have no scientific foundation. The teaching of scientific attitudes regarding specific situations is thought to be an important part of remedial instruction regarding unfounded beliefs.

In the experimental study of unfounded beliefs related to cer-

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[1] "A Study of Unfounded Beliefs Among High School Seniors." Lundeen, Gerhard E., and Caldwell Otis W., *Journal of Educational Research*, XXII, pp. 257–273, 1930.

[2] "Students Attitudes Regarding Unfounded Beliefs." Caldwell, Otis W., and Lundeen, Gerhard E., *Science Education*, XV, pp. 246–266; 1931.

[3] "An Experimental Study of Superstitions and Other Unfounded Beliefs as Related to Certain Units of General Science." Caldwell, Otis W., and Lundeen, Gerhard E., Bureau of Publications, Teachers College, Columbia University, p. 138; 1932.

[4] "Sources of Superstitious Beliefs." Maller, J. B., and Lundeen, Gerhard E., *Journal of Educational Research*, XXVI, pp. 321–343, 1933.

tain units in general science, it was necessary to include subject matter that is commonly used in these units as well as that dealing with unfounded beliefs. In order to present fully the method used in the earlier experiments, all of the textual material was published. In the experiment to be presented in this paper, discussions are presented of unfounded beliefs which were included in the biological unit "*Heredity and Its Applications*," but the factual elements commonly used in the unit are omitted. The technique of this unit was similar to that of the units of general science previously published. The factual elements that were used but not discussed in this publication and the unfounded beliefs are listed in Table V. Experimental data obtained from the use of the unit in public schools, and the conclusions from those data are presented. The discussions relating to the eight unfounded beliefs are presented in the following sections in the same form as used by the pupils in the experiment.

PART OF THE UNIT DEALING WITH UNFOUNDED BELIEFS

Is it true that in former times the average human life was much longer than in present times? The ability to live to an extreme old age that is called longevity, is an inherited tendency. Studies indicate that longevity runs in families. Individuals of certain families are long-lived and their children tend to have the capacity to live for many years. The children of short-lived families also tend to be short-lived. Undoubtedly, heredity is the greatest single factor that determines the length of human life.

Among primitive races only the individuals who had strong resistance against disease lived to maturity; the others died in infancy or in their early years. The individuals who lived the longest also left more offspring to inherit and pass on to succeeding generations this hereditary characteristic of longevity. This favored a strong and hardy race. Thus by a process of natural selection, the life span of the human race was increased. The average span of human life is longer today than it has been during any previous period of which we have any record. The evidence indicates that people during the time of the Egyptians on the average did not live much over thirty years. Today the expectancy of life at birth in the United States is about fifty-eight years. This increase in the average length of life is due to the advance of preventive medicine, control of communicable diseases, better ways of living, and great reduction in infant mortality. The application of the science of health has reduced the death rate in early life. The result is that the average life of human beings has been lengthened. This does not mean that the length of life can be indefinitely increased by the prevention of disease, hygienic living and the improvement of the environment. If all communicable diseases could be eradicated and the environment be made ideal, people would still die of old age. Some individuals because of hereditary characteristics or defects or lack of proper care become old sooner in life than do others. Individuals vary in the capacity to live long as they do in other respects. Much may be done

from a clinical point of view to prolong the life of individuals. To increase the capacity for longevity when medical science has done all that it can do and when environmental factors have been made the best possible, is a problem of heredity. The problem is to develop a race of men who are free from hereditary defects and who have the inherited quality for long life.

The notion that in the old days individual human beings lived longer than they do now is largely due to statements found in ancient literature giving the age of the old heroes as several hundred years. It is supposed that the term "years" that was used in the early days was very likely a much shorter unit of time than our year, possibly something like the length of one of our months. The fact is that, as far back as we have reliable records, some individuals lived to be as old as individuals do now. The average length of human life, however, is much longer today than ever before.

Are fat people good-natured? In general the tendency to deposit fatty tissue is inherited. This tendency, however, may be controlled to a considerable extent. A person's temperament or disposition is also largely a matter of inheritance although it may be cultivated, directed, and controlled to a considerable degree. Whether one inherits tendencies toward good digestion and good qualities of tissue building and repair determines to a large extent whether he shall be fat or thin.

Fat people are not necessarily good-natured. The tendency to deposit fat and the tendency toward a good-natured disposition are not linked together in inheritance. That is, a person may inherit a kind of metabolism that is conducive to store fatty tissue in the body, and may also inherit or develop a bad disposition. There are examples of men who are fat and whose temperament is not pleasing. Individuals who are thin and who are not endowed with the tendency to deposit fat, may be good-natured and may have charming personality.

There may, however, be some truth to the idea that fat people are more likely to have a good disposition than individuals who are thin. Apparently deposits of fat tend to produce a feeling of well-being which brings about a state of satisfaction and contentment. In other words, the bodily reactions of a fat person are such as to provoke good-natured behavior. Also, people who have a good digestion and who are inclined to fatness may be more contented and pleasant because of the fact that they are free from digestive or nutritional difficulties which may cause some other people to be thin. In such cases, fat people would likely be better natured than the others.

Are mental disorders caused by over-study? The word "insanity" is applied to a group of mental diseases. A mental disease may be due to a combination of factors. Some mental diseases incline to recur in certain families, and seem to be largely determined by heredity. Mental derangements are more likely to occur among people who have inherited certain nerve defects or weaknesses than among people who are free from such defects. Exhaustion as a result of over-study may be instrumental in bringing about a nervous disorder. The popular opinion that a great deal of mental work causes insanity is not correct. Over-activity in intellectual effort would not be likely to produce mental disorders any more than would anxiety over loss of friends, financial worry, or other strains or tasks which

require an excessive expenditure of nervous energy. Abnormal mental types are sometimes found among those who devote much time to learning and who do not find satisfaction in recreation and social entertainment. Over-study is possibly a symptom of unbalanced mind and habits rather than a cause of defective mentality.

Are children of first cousins likely to be feeble-minded? The assumption that if close relatives marry, their children are likely to be mentally or physically defective has been believed for many generations. The experience of the race indicates that the children of parents who were cousins are not necessarily defective. Charles Darwin, the great scientist, married his first cousin and their four sons all became able and prominent men. Other examples of this kind are well known. The instances of defective offspring resulting from cousin marriages are much more numerous and have impressed people more than when such offspring are normal. In many countries, laws have been enacted to prohibit the marriage of close relatives. In some of the United States, the marriage of those who are legally cousins is unlawful, although this relationship may not be a close biological relationship but a relationship caused by remarriage of one or both parents.

The popular belief that children of first cousins are likely to be feeble-minded is not supported by facts. There is no biological reason for the conclusion that the marriage of cousins will result in defective offspring. The fact is, that cousins who come from fine human stock, would be less likely to have defective children than would others whose ancestry is not so good. On the other hand, if first cousins come from a family in which feeble-mindedness is found, there is twice as much chance for their children being feeble-minded as if but one of the parents came from such a strain. The relative purity of the stock is the deciding factor and not the cousin relationship.

A hereditary defect sometimes acts as a recessive Mendelian character. Feeble-mindedness is thought to be a character of this kind which is transmitted from parent to offspring according to what is called the Mendelian ratio of inheritance. In developing his ideas Mendel used plants as his experimental material. He distinguished between three types of plants among garden peas in regard to height, color, and other characters. Since the time of Mendel's work, and based upon it, three types of individuals have been determined in regard to feeble-mindedness. They are the purely normal persons, the apparently but not really normal ones, and those known to be feeble-minded. The purely normal individuals do not carry any of the determining units or genes for feeble-mindedness. Their genes are determiners for normal mindedness. In the apparently but not really normal person, part of the genes are determiners for normality and part for feeble-mindedness. Since the normal genes are dominant, these individuals are apparently normal but really carry genes of feeble-mindedness, and may transmit this quality to their offspring.

If the purely normal person marries one who is feeble-minded, all their offspring will apparently be normal though they will have the recessive determiners of feeble-mindedness. We can illustrate this by use of a formula. Let (N) represent the genes for the purely normal person, and (F) the genes of the feeble-minded person. When the fertilized egg cell is formed, all the combinations of the genes of the new individual results in

(NF). In this NF offspring all would be normal since normal-mindedness is dominant over feeble-mindedness. The genes (F) for feeble-mindedness are present but do not make the person feeble-minded. If two persons apparently normal but carrying recessive genes of feeble-mindedness should marry, some of their children may be feeble-minded. The possible combinations of the genes in such a case may be represented as follows:

$$NF \times NF = NN + 2NF + FF.$$

This means that some offspring are normal, some apparently normal though carrying the recessive genes of feeble-mindedness, and some are clearly feeble-minded.

The children of purely normal parents will not be feeble-minded as their parents do not have any genes of feeble-mindedness in their heredity. The offspring of two feeble-minded parents are usually all or nearly all feeble-minded. Goddard traced 482 descendants from 144 feeble-minded matings and of those 476 were feeble-minded. On the other hand not one of the descendants of the Jonathan Edwards family which represents good heredity have been found to be feeble-minded.

The question therefore whether first cousins should be allowed to marry depends upon the family pedigree. If the genes of feeble-mindedness are present in the family, cousin marriage will increase the probabilities for two such genes to combine and produce feeble-minded children. Cousins in such cases are very likely to carry the same defect. When the heredity is excellent, however, the marriage of first cousins may be desirable, since any exceptional quality in the family, even though dependent upon recessive genes, might reappear in the offspring. There can be no biological objection to the marriage of first cousins of good heredity. It should be encouraged and laws that have been enacted against such unions should be modified and adjusted to conform with present knowledge, if only accompanying laws could be enforced to prevent the continuance of poor qualities being passed into succeeding generations.

Will a child be influenced by what the mother sees or thinks before the child is born? There is a common idea that a mother can influence her unborn child by what she sees or thinks. According to this belief, the child may become talented and may develop interests and abilities according to the mother's habits and practices. Physical appearance and physical deformities that the child may have are often thought to have been caused by what the mother saw previous to the birth of the child. These ideas have no evidence to support them.

There are no nerve connections between the mother and the developing embryo. The vital connection between the mother and her unborn child is through the blood stream. It is, therefore, impossible for the mother to affect her child by what passes through her mind except in so far as it may affect the composition of the blood. If certain poisons or toxic substances are present in the mother's blood, they may pass to the unborn child. It is also true that if the mother is under-nourished, the health of the child and its development would be affected. The direct effect that the mother may have upon the development of her child is entirely of a nutritive nature and would not produce changes in the child's mental or artistic inheritance. As previously explained, it is accepted by scientists that the genes in the chromosomes of the sex cells are the carriers of the

hereditary qualities from parent to offspring. Therefore, the combinations of genes and chromosomes when the sex cells combine determines the inherited qualities of the child. The inborn or inherited tendencies are not affected by the wishes of the mother. If a mother spends a great deal of time looking at paintings or other works of art she may be happier and more pleasantly occupied than she might otherwise be. This might be good for her health and thus be good for the nutrition and development of her child, but her child will not as a result be endowed with an increased artistic ability because of the mother's actions. If she cultivates her musical ability by singing, by playing musical instruments, or by listening to beautiful and inspiring music, her child will not have greater musical ability because of this. It has not been proved that acquired characteristics are inherited. Artistic, musical or literary abilities or capacities to learn are inherited, and are not acquired through any environmental factors. The fact that a parent may have capacity for music or art indicates that the child may inherit this capacity but ability to perform in music or art must be learned. Those who are fortunate enough to have inherited the largest capacity to learn music are the ones who have the chance to become the greatest musicians. After birth, an environment which helps musical development is likely to contribute to the learning which inheritance has made possible.

Are birth marks caused by what the mother sees or touches before the child is born? Birth marks usually appear as patches of red or purple discolorations in the skin. They occur most frequently about the region of the face and head but may appear in other parts of the body. The discolorations are thought to be due to excessive development of blood vessels near the surface of the skin. Birth marks are not hereditary defects but are congenital, that is, present at birth. They are probably caused by injuries or lesions of the tissues of the developing embryo and the nutritive maternal structure known as the placenta. A mark or defect that a child may possess at birth was not caused by what the mother had previously seen, touched or experienced. As mentioned previously, there are no nerve connections between mother and child, hence there could be no possibility for a mother to mark the child by thoughts that passed through her mind. There are no proved facts to support the assertion that a mother can mark her child by what she may experience. The mother's fear in this regard is unfounded, as is also a common tendency to criticize parents whose child may possess a birth mark.

Does a heavy growth of hair on a person's chest and limbs indicate great physical strength? A heavy growth of hair on a person's body, especially on the chest, is commonly considered an indication of physical strength. Individuals and families differ in the inherited tendencies regarding the development of hair. They also differ in the inheritance of body form such as stature, height, stoutness and physical strength. Individuals inherit independently their capacity for physical strength, and the tendency to develop a heavy growth of hair on the body. Thus a person having a strong physique may or may not have a heavy growth of hair on his body. Many physically strong men have very little growth of hair on their chests and limbs while others may be physically weak and may have an abundance of hair on their bodies. No relationship has been proved to exist between the growth of hair on a person's body and his physical vigor.

Does the theory of evolution imply that men descended from apes? The theory of organic evolution asserts that complex organisms of the past were derived from simpler life of still earlier times. According to this theory life as it exists today originated from previous life, and has slowly and progressively changed during past ages from simple to complex living things. Higher types of plants and animals have come from earlier and more simple forms.

Discussions of the evolution of life are often associated with the idea that man "descended from the monkey." Most biologists do not believe that man has developed from the apes but that both man and apes have descended from common ancestry that existed long ago. This does not mean that during the course of organic development monkeys gave rise to men, but it does indicate a common origin, as different branches of a tree have developed from the same stem.

Similarity in structure may indicate relationship. The greater the similarity, the closer the relation that is indicated. For example, we may infer that dogs are more closely related to wolves than to birds because of a greater structural resemblance between dogs and wolves. In some structures monkeys are like men and these similar structures can be explained only upon the basis of biological relationship. In the same way the similarity between human structure and that of many other animals indicates man's kinship to lower life. A study of detailed structures also indicates that certain human structures such as the vermiform appendix, pineal gland, wisdom teeth, rudimentary tail, and others, are part of man's heritage from animals of ancient days. Many of these more or less useless organs or vestiges, which persist in man's body, are also found in lower mammals and are useful to those animals. As the human embryo develops from the fertilized egg, it passes through various stages. In some of these stages it possesses certain structures which were present in the earlier ancestors. At one stage, for instance, the human embryo has gill slits similar to those found in fish.

The study of fossils shows that there has been progressive development of life from the simple to the complex. Fossils show that there were many kinds of organisms which once lived that do not now live. Fossils also show that new forms appeared in succeeding ages. A great variety of these fossils may be found in the sedimentary deposits of the earth. The complex forms of life appear only in the more recent deposits, while the simple forms are found in the older rocks. A few remains of primitive man have been discovered in the most recent rocks.

DISCUSSION OF THE EXPERIMENT

The cooperating schools. The unit to which we have already referred was experimentally used in biology classes of two high schools in the state of Pennsylvania. School A was represented by 173 sophomore boys, 7 classes and 7 different teachers. School B involved the cooperation of one teacher, 2 classes and 58 high school seniors. Nineteen of these pupils were boys and 39 were girls. The average age of the sophomore boys was 16

years and of the senior boys and girls 18 years. The data presented are based upon the complete records of 231 pupils.

The test used and general results. To determine the effect of remedial instruction regarding unfounded beliefs it was necessary to measure the pupil's achievements with respect to the special items of the test dealing with such beliefs. A test consisting of two parts, 35 true-false statements and 35 statements of the multiple-choice type was given before and after instruction. The two parts of the test involved identical items. Eight items in each part of the test involved unfounded beliefs. The other items dealt with concepts usually included in a unit dealing with the subject of heredity. The scores which the pupils made on the test were determined by combining the scores of the two parts, that is, the correct responses minus the incorrect responses of the true-false part were added to the number of correct responses of the multiple-choice part. The possible score on the items regarding unfounded beliefs was 16 and for all items of the test 70. The average scores and variability regarding unfounded ideas in the initial and final tests and the average increase in desirable responses after a period of instruction were determined for the total number of pupils included in the study. The data are presented in Table I. It may be seen from the table

TABLE I
ACHIEVEMENT REGARDING UNFOUNDED BELIEFS

Group	Initial Test Mean	Initial Test S.D.	Final Test Mean	Final Test S.D.	Gain Mean	Per cent
Sophomore Boys	6.69	3.22	12.38	3.32	5.69	35.6
Senior High School Pupils	10.62	3.34	14.60	1.65	3.98	24.9
Total Number of Pupils	7.68	4.17	12.94	3.54	5.26	32.9

that the average pupil made a score of 7.68 or 48 per cent of the possible score on the initial test. The score on the final test was 12.94 or 80.9 per cent of the total number. The average gain in achievement after a period of instruction was 5.26 or 32.9 per cent.

Achievement of Sophomore Boys and of High School Seniors. The sophomore boys and high school seniors were studied separately due to their difference in age and because the seniors had previously studied biology in high school. Table I reveals that

senior boys and girls made better achievement records on the initial and final tests than did the sophomore boys. The high school seniors made an average score of 10.62 or 66.4 per cent on the initial test and a score of 14.60 or 91.3 per cent on the final. The average score for the sophomore boys was 6.69 or 41.8 per cent on the initial test and 12.38 or 77.4 per cent on the final test. On the initial test the high school seniors exceeded the sophomore boys by an average score of 24.6 per cent (66.4–41.8). This indicates that the average senior possessed previous to any remedial instruction more rational attitudes regarding the unfounded ideas than did the sophomore boys. The achievement in terms of average gain was greater, however, among the sophomore boys than among the high school seniors. The sophomore boys made an average gain of 35.6 per cent in desired responses on the items dealing with unfounded beliefs after they had studied the unit while the gain made by the high school seniors was much less, being 24.9 per cent. The greater gain among the sophomore boys was probably due to a greater possibility for improvement since their score on the initial test was considerably lower.

Achievement of Individual Classes. The effect of instruction in regard to attitudes concerning unfounded beliefs was determined for each class. The achievement records of individual classes are presented in Table II. It is seen from the table that there was considerable variation in achievement between classes. The score in the initial test varied from 11.04 or 69 per cent of class II in school B to 5.43 or 33.9 per cent of class V in school A. In the final test the difference between the scores of the various classes was less than it was in the initial test. The lowest score in the final test was 11.24 or 70.3 per cent and the highest was 14.61 or 91.3 per cent. The gain in achievement after instruction varied from 47.1 per cent to 22.3 per cent. The table shows that classes within the same school representing sophomore boys varied in their achievement. For example in class II of School A, the average pupil in the initial test made a score of 8.38 or 52.3 per cent while the average pupil in class V made a score of only 5.43 or 33.9 per cent of the possible score. Class V made a gain of 47.1 per cent in desirable responses after an intervening period of instruction while class IV made an average gain of 28 per cent. All classes represented in the experiment, however, made substantial gains in desired reactions regarding unfounded ideas as a result of remedial instruction.

TABLE II
ACHIEVEMENT REGARDING UNFOUNDED BELIEFS BY INDIVIDUAL CLASSES

Class	Number of Cases	Initial Test Mean	Initial Test S.D.	Final Test Mean	Final Test S.D.	Gain Mean	Gain Per cent
School A							
I	26	6.62	3.61	12.42	2.80	5.80	36.3
II	26	8.38	3.33	14.04	2.17	5.66	35.4
III	29	6.45	3.03	11.76	3.87	5.31	33.2
IV	21	6.76	2.07	11.24	3.11	4.48	28.0
V	23	5.43	2.63	12.96	3.19	7.53	47.1
VI	20	7.45	3.79	12.75	3.43	5.30	33.1
VII	28	5.86	2.62	11.54	2.90	5.64	35.3
School B							
I	30	10.23	3.67	14.60	1.21	4.37	27.3
II	28	11.04	2.86	14.61	1.73	3.57	22.3

Unfounded Beliefs and Factual Elements. Although the chief aim of this experiment was to study the effect of instruction in an attempt to develop desirable attitudes concerning unfounded beliefs, the outcomes of teaching the factual elements of the unit are presented for the purpose of comparison.

Achievement in regard to the major concepts and understandings of the unit is presented in Table III. The average score for the total number of pupils on the initial test regarding the unfounded beliefs was 7.68 or 48 per cent of the possible score (Table I) while in regard to all items of the test which included the unfounded beliefs the average score was 36.20 or nearly 52 per cent of the maximal score, as indicated by Table III. This shows that the average pupil possessed before any instruction

TABLE III
ACHIEVEMENT REGARDING FACTUAL ELEMENTS

Group	Initial Test Mean	Initial Test S.D.	Final Test Mean	Final Test S.D.	Gain Mean	Gain Per cent
Sophomore Boys	33.97	9.41	49.75	10.08	15.78	22.5
Senior High School Pupils	42.87	9.24	60.10	6.13	17.23	24.6
Total Number of Pupils	36.20	10.13	52.34	10.28	16.14	23.1

was given on the unit more accurate information regarding the factual elements than in regard to the unfounded beliefs. The average senior, however, scored higher regarding the unfounded ideas previous to instruction than in regard to the factual elements. The respective scores were 66.4 and 61.2 per cent of the total score in each case. The average sophomore scored 6.7 per cent (48.5–41.8) lower with respect to the unfounded beliefs than in regard to all the items of the test.

A comparison of Tables I and III shows that the seniors made a greater per cent gain in achievement regarding the regular subject matter of the unit (unfounded beliefs included) as a result of instruction than did the sophomore boys, although the seniors had a considerably higher score in the initial test. The sophomore boys as revealed in Table I made a greater gain in desirable reactions toward unfounded beliefs than did the high school seniors. An examination of the two tables reveals that the average gain in correct responses after instruction was greater regarding unfounded beliefs than it was for the factual elements usually included in a unit of this kind. Considering the total number of pupils the average gain in desired responses was almost 10 per cent (exactly 9.8 per cent) greater regarding the special items dealing with unfounded ideas than for all the items of the test including these special items. Among the high school seniors the achievement in terms of per cent gain was approxi-

TABLE IV

ACHIEVEMENT REGARDING FACTUAL ELEMENTS BY INDIVIDUAL CLASSES

Class	Number of Cases	Initial Test Mean	Initial Test S.D.	Final Test Mean	Final Test S.D.	Gain Mean	Gain Per cent
School A							
I	26	35.46	10.44	49.19	9.74	13.73	19.6
II	26	37.38	9.03	58.19	8.87	20.81	29.7
III	29	34.83	9.62	49.24	9.88	14.41	20.6
IV	21	31.86	8.94	48.29	10.95	16.33	23.3
V	23	30.61	6.51	46.48	8.14	15.87	22.7
VI	20	35.90	9.15	51.65	9.21	15.85	22.6
VII	28	31.50	9.24	45.39	8.35	13.89	19.8
School B							
I	30	40.69	9.16	59.13	6.73	18.44	26.3
II	28	45.21	8.74	61.14	5.25	15.93	22.8

mately equal for both the unfounded ideas and the factual elements, being slightly greater for the unfounded beliefs. Among the sophomore boys the average gain after a period of instruction was 13.1 per cent greater for the unfounded beliefs than for the factual elements.

Table IV presents the achievement by individual classes in regard to all the items of the test. By comparing Tables II and IV it is seen that each class made a greater gain in achievement concerning the unfounded ideas as a result of instruction than concerning the factual elements of the unit with the exception of class II in school B.

SUMMARY AND CONCLUSIONS

1. The unfounded ideas considered in this report were shown by previous studies to be widespread.

2. The results of this study show that the knowledge foundations for desirable attitudes concerning certain facts may be developed by remedial instruction.

3. As a result of instruction the average per cent gained in desired responses was greater regarding the unfounded beliefs than for all the items of the test. The average pupil gained 32.9 per cent in desirable responses regarding the unfounded beliefs and 23.1 per cent regarding the factual elements including the special items dealing with unfounded beliefs.

4. The average senior possessed the knowledge foundations for more desirable attitudes regarding the unfounded ideas previous to instruction than did the average sophomore boy.

5. Senior high school pupils made higher average scores on the initial and final tests regarding both the unfounded ideas and factual elements of the unit. The sophomore boys made a greater average gain in desirable responses concerning the unfounded beliefs after a period of instruction while the seniors made a slightly greater gain on the entire test.

6. Discussions of common unfounded beliefs included in this study may serve as a basis for motivation of pupil's interest in the subject of heredity and may serve as useful material in teaching scientific attitudes.

7. This study gives no evidence regarding whether the gains in desirable attitudes will persist. It seems reasonable to suppose that their persistence may be no less than knowledge of the facts involved.

TABLE V*

PER CENT OF CORRECT RESPONSES TO EACH ITEM OF TRUE-FALSE (FORM A) AND MULTIPLE-CHOICE (FORM B) OF THE INITIAL AND FINAL TESTS

	Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
(T)	1A. Examples of biological inheritance are, eye color, musical talent and artistic ability	69	92	23	
(A)	1B. Examples of biological inheritance are (A) eye color, musical talent, and artistic ability, (B) religion, education, and government, (C) art, music, and literature, (D) homes, schools, and churches	92	97	5	
(T)	2A. Individuals possess unequal mental and physical characteristics	83	84	1	
(D)	2B. Individuals possess (A) the same mental capacities (B) same physical characteristics (C) equal opportunities for an education (D) unequal mental and physical characteristics	71	80	9	
(T)	3A. The theory of natural selection was originated by Darwin	52	74	22	
(D)	3B. The theory of natural selection was originated by (A) De Vries (B) Lamarck (C) Burbank (D) Darwin	37	44	7	
(T)	4A. The fact that organisms exhibit individual differences is known as variation	75	92	17	
(A)	4B. The fact that organisms exhibit individual differences is known as (A) variation (B) adaptation (C) natural selection (D) hybrids	54	77	23	
(F)	5A. Natural selection results in the elimination of the best adapted	73	75	2	
(B)	5B. Natural selection (A) preserves the unfit individuals (B) is produced by the struggle for existence (C) results in the elimination of the best adapted (D) causes an overproduction	50	77	27	

* This table is based upon 100 random selected cases of the total 231 pupils which provided data for the experiment. The true-false questions are marked T (true) or F (false). The completion questions are marked A, B., C, or D, to indicate which part of the answer is correct.

TABLE V (*Continued*)

	Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
(T)	6A. One factor that causes a struggle for existence is an over-production of individuals	88	98	10	
(A)	6B. One factor that causes a struggle for existence is (A) an overproduction of individuals (B) an abundance of food (C) heredity (D) a good environment	81	95	14	
(F)	7A. The achievements of an individual are determined entirely by the opportunities of his environment	65	80	15	
(C)	7B. The achievements of an individual are determined (A) entirely by his heredity (B) entirely by the opportunities of his environment (C) by both his heredity and the opportunities of his environment (D) by his physical strength	81	93	12	
(F)	8A. The hereditary qualities are transmitted from parents to their offspring through the nerve cells	88	90	2	
(D)	8B. Hereditary qualities are transmitted from parents to their offspring through (A) the nerve cells (B) blood (C) body cells (D) sex cells	76	90	14	
(F)	9A. When Mendel crossed pure tall peas with pure dwarfs, the hybrid generation were all dwarf plants	91	99	8	
(D)	9B. When Mendel crossed pure tall peas with pure dwarfs, the hybrid generation (A) were all dwarf plants (B) had both tall and dwarf plants (C) were of medium size (D) were all tall plants	26	72	46	
(T)	10A. When the hybrid generation of tall peas were crossed among themselves the offspring consisted of 75 per cent tall plants and 25 per cent dwarf plants	74	85	11	
(D)	10B. When the hybrid generation of tall peas were crossed among themselves the offspring consisted of				

TABLE V (*Continued*)

Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
(A) all dwarf plants (B) all tall plants (C) 75 per cent dwarf plants and 25 per cent tall plants (D) 75 per cent tall plants and 25 per cent dwarf plants	50	76	26	
(F) 11A. If sweet peas which are pure for the yellow color of their seed are crossed with sweet peas which are pure for green color of the seed coat the plants in the hybrid generation will all have green seed when mature	73	75	2	
(A) 11B. If sweet peas which are pure for the yellow color of their seed are crossed with sweet peas which are pure for the green color of the seed coat, the plants in the hybrid generation (A) will all have yellow seed (B) will all have green seed (C) will have a mixture of green and yellow (D) may have any color	11	55	44	
(T) 12A. If a plant or animal that is pure for a unit character is crossed with another that is pure for an opposite unit character one of the contrast characters is dominant and the other is recessive in the offspring	76	95	19	
(B) 12B. If a plant or animal that is pure for a unit character is crossed with another that is pure for an opposite unit character (A) both characters appear (B) one is usually dominant and the other recessive (C) neither character appears (D) the characters always blend in the offspring	62	91	29	
(F) 13A. The fact that contrasting unit characters are separated and reappear in the F_2 generation is known as the law of pure breeds.	49	63	14	
(D) 13B. The fact that contrasting unit characters are separated and reappear in the F_2 generation is known as the law of (A) pure				

TABLE V (*Continued*)

		Items	Initial Test	Final	Gain	Loss
		breds (B) chance (C) dominance (D) segregation	25	67	42	
(F)*	14A.	Feeble-minded children are primarily a result of a first-cousin marriage	81	86	5	
(B)*	14B.	Feeble-minded children are primarily a result of (A) the influence of environment (B) defective heredity (C) a first-cousin marriage (D) a lack of nourishment	76	88	12	
(T)	15A.	Physical characteristics such as color of the hair, complexion, body form and stature are inherited	92	96	4	
(A)	15B.	Physical characteristics such as color of the hair, complexion, body form and stature (A) are inherited (B) are caused entirely by environment (C) depends primarily upon the diet (D) are determined by the kind of exercise	89	100	11	
(F)*	16A.	People who are fat always have a good disposition	74	94	20	
(B)*	16B.	People who are fat (A) always have a good disposition (B) sometimes have a bad disposition (C) always inherit the tendency to be good natured (D) always have a bad disposition	39	72	33	
(F)*	17A.	A heavy growth of hair on the body indicates physical strength	79	98	19	
(B)*	17B.	A heavy growth of hair on the body (A) indicates physical strength (B) has no relation to physical strength (C) is an acquired characteristic (D) is characteristic of all men	24	77	53	
(T)	18A.	Characteristics acquired during the life time of an organism are not transmitted to his offspring	52	87	35	
(B)	18B.	Characteristics acquired during the life time of an organism (A) are transmitted to his offspring (B) are not transmitted to his				

TABLE V (*Continued*)

Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
offspring (C) has been experimentally demonstrated to be inherited (D) are thought to be inherited by most biologists....	25	67	42	
(F)* 19A. A mother can determine the interests and tendencies that her child will develop as it grows to maturity by what she sees or thinks before the child is born...	85	98	13	
(C)* 19B. The idea that a mother can determine the interests and tendencies that her child will develop as it grows to maturity by what she sees or thinks before the child is born is (A) true (B) probably true (C) a false opinion (D) approved by men of science.......	68	98	30	
(F)* 20A. Birth marks are caused by certain things that the mother may see or touch before the child is born.	81	98	17	
(C)* 20B. The idea that birth marks are caused by certain things which the mother may see or touch before the child is born is (A) based upon facts (B) an example of a causal relationship (C) based upon the opinions of uninformed people (D) based upon the opinion of good authority..........	56	82	26	
(F) *21A. Insanity or mental disorders are caused by too much study......	76	86	10	
(C) *21B. Insanity or mental disorders are caused by (A) too much study (B) tuberculosis (C) inherited tendencies (D) recreation......	84	92	8	
(F) *22A. During ancient times some individuals lived much longer than they do at the present time.........	38	73	35	
(A) *22B. The idea that during ancient times some individuals lived much longer than during the present is (A) false (B) supported by reliable records (C) based upon a correct interpretation of ancient literature (D) confirmed by scientific investigation........	38	80	42	

TABLE V (*Continued*)

		Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
(T)	23A.	The increase in the average length of human life during recent times is due to a reduced death rate in early life	57	81	24	
(A)	23B.	The increase in the average length of human life in recent times is due to (A) a reduced death rate in early life (B) increased expectancy of life above 60 years (C) a great improvement in the heredity of the human race (D) more leisure time	21	42	21	
(T)	24A.	Selection that is directed by man to develop qualities which he desires to promote in plants and animals is called artificial selection	82	92	10	
(C)	24B.	Selection that is directed by man to develop qualities which he desires to promote in plants and animals is called (A) natural selection (B) survival of the fittest (C) artificial selection (D) hybridization	35	76	41	
(T)	25A.	The improvement of the human race through the control of heredity is the science of eugenics	70	86	16	
(B)	25B.	The improvement of the human race through the control of heredity is the science of (A) euthenics (B) eugenics (C) biology (D) genetics	38	68	30	
(T)	26A.	Feeble-minded individuals should be prevented from having children	90	99	9	
(C)	26B.	Feeble-minded individuals (A) are an asset to society (B) should be allowed to have children (C) be prevented from having children (D) are capable to do productive work	80	91	11	
(F)	27A.	The heredity of the human race may be improved by war	94	93	1	
(C)	27B.	The heredity of the human race may be improved by (A) war				

TABLE V (*Continued*)

		Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
		(B) environment (C) the application of the laws of inheritance (D) increasing the number of feeble-minded	56	76	20	
(F)	28A.	Too much education has a tendency to lower the quality of the human stock	87	90	3	
(C)	28B.	One factor which has a tendency to lower the quality of the human stock is (A) the abolition of war (B) too much education (C) small families among the more intelligent classes (D) small families among the lower classes of society	56	78	22	
(F)	29A.	The offspring of feeble-minded parents are usually normal	83	93	10	
(B)	29B.	The offspring of feeble-minded parents are usually (A) normal (B) feeble-minded (C) brilliant (D) above the average in intelligence	87	98	11	
(T)	30A.	New forms of plants and animals have been produced as a result of selection and hybridization	90	95	5	
(D)	30B.	New forms of plants and animals have been produced as a result of (A) proper feeding (B) special care (C) an improved environment (D) selection and hybridization	78	95	17	
(T)	31A.	Organic evolution asserts that the higher forms of life have developed from lower forms	88	87	1	
(C)	31B.	According to organic evolution, life has (A) not changed during the past (B) developed from higher forms to lower (C) developed from lower forms to higher (D) originated from organic matter	58	96	38	
(F)	32A.	The theory of evolution explains the origin of life	25	52	27	
(B)	32B.	The theory of evolution explains (A) the origin of life (B) the relationship of plants and animals (C) meaning of life (D) possibilities of the future of mankind	23	33	10	

TABLE V (*Concluded*)

Items	Per cent of Correct Responses Initial Test	Final	Gain	Loss
(T) 33A. The evolution of life is based upon good evidence	66	78	12	
(A) 33B. The evolution of life (A) is based upon good evidence (B) has no basis in fact (C) has been definitely proven (D) is universally thought to be true	29	57	28	
(T) 34A. A study of fossils indicates that life has changed during former times	83	98	15	
(A) 34B. The study of fossils indicates that (A) life has changed during the past (B) no change has taken place (C) the higher forms of life have existed on the earth before the lower forms (D) the higher plants and animals have always existed	75	91	16	
(F) *35A. Biologists claim that men decended from the monkeys	65	96	31	
(C) *35B. Biologists claim that (A) men descended from the monkeys (B) monkeys descended from men (C) both men and monkeys originated from a common ancestor (D) men and monkeys show no similarity	34	84	50	

PHYSICAL INSTRUMENT USED TO STUDY HEART

One of the newer physical instruments has been put to use in the study of the human heart, members of the American College of Physicians heard at their meeting at Montreal.

The oscillograph has been adapted to this use by Dr. William D. Reid of the Evans Memorial of Massachusetts Memorial Hospitals and Prof. Samuel H. Caldwell of Massachusetts Institute of Technology.

At present, physicians are using an instrument known as the string galvanometer for making records of heart beats. This probably will be replaced by the oscillograph apparatus which Dr. Reid described here today. However, he pointed out that for the present, physicians must continue to use the older instrument, while records and standards are being obtained for the new one.

The new instrument gives a more complete and detailed picture of the condition of the heart, it appeared from Dr. Reid's description of it and report of its use. The oscillograph is not so sensitive as the string galvanometer but works at much higher frequencies.—*Science Service.*

COSMIC RAYS

By G. E. Owen
Antioch College, Yellow Springs, Ohio

On the eighth day of May of last year a party of explorers scaling Mount McKinley, Alaska, found the dead body of a young physicist, Theodore Koven, on the Muldrow Glacier. There were indications that Koven and his colleague, Allen Carpe, had climbed the glacier to make some scientific measurements and had fallen into a concealed crevasse. Koven managed to get out but soon died of his injuries and exposure. On August eighteenth of last year Auguste Picard, a Belgian physicist, for the second time ascended to a height of more than ten miles above the earth in a free balloon of his own design. Other physicists, under the direction of Professor A. H. Compton, are making measurements at the summit of Nevado de Toluco, 14,950 feet above sea level in Peru, in Hawaii, Australia, New Zealand, Panama, Baffin Land, South Africa, India, the South Seas, Patagonia, Spitzbergen, and Chile.

We have been told that scientific research has all the elements of adventure found in exploration, the expensive preparation, the long, arduous (and sometimes tedious) labor towards the goal, very often disappointment and occasionally the thrill that comes with success (witness Archimedes, having discovered the law of buoyancy, rising from his bath in his excitement and walking through the streets of Athens unclad). But research in physics does not usually involve journeys to the far away places of the earth and such spectacular risk of life and health such as was undertaken by Picard, Koven, Carpe and others. Why do these scientists wander so far from their well equipped laboratories and carry their instruments to the North and South magnetic poles, under the surface of the snow-fed lakes of the Andes and the Sierras, to the glaciers of the Alps and Alaska, down into deep pits and mines and up into the upper atmosphere in airplanes and balloons? They are tracing a very minute electrical leak, a leak so minute that if your automobile battery lost its charge only through this leak it would not need to be recharged in millions of years. But if you ask them, "Why so much trouble and risk for such a small leak?" they may answer like the Canadian prospector who has found traces of a valuable mineral but has not yet found the lode, "Maybe it is small but it begins to look like something BIG"; so big in fact that no less

an authority than J. H. Jeans estimates that the cause of that little leak is a stream of energy equal to one-tenth of all the energy in the form of radiation in the universe; so big that it may cause a complete revolution of our ideas of the evolution of the universe.

One of the earliest of electrical instruments is the gold leaf electroscope, consisting essentially of two gold leaves hanging from a metal rod and enclosed in a metal box or a glass bottle, the leaves being insulated from the container by a plug of sulfur or other non-conducting material. When such an instrument is charged (as by contact with a rubber fountain pen which has been rubbed on your sleeve) the leaves repel each other and stand apart. If the electroscope is carefully designed it can hold this charge for a long time, but careful examination will show that the leaves are always gradually falling together—the charge is leaking away. Some of it, a very little, is conducted through the sulfur plug to the outside case and thence to the ground, more passes over the surface of the plug which can never be kept entirely free of a film of moisture and impurities, and some passes from the leaves to the case through the air which is always slightly conducting. A gas such as air becomes conducting if some negative electrons have been separated from atoms of the gas leaving the atoms positively charged. For example, if the leaves of an electroscope are charged positively and the air surrounding the leaves is slightly ionized, i.e., contains some atoms which have lost one or more electrons, the electrons will be attracted to the positively charged leaves where they will partially neutralize the charge of the leaves. The positive charge will be repelled to the case of the electroscope with the net result that the leaves lose their charge and the case becomes positively charged. This effect would stop when all the electrons had been drawn to the leaves if it were not for the fact that the air is being ionized continually by various agencies such as heat, light, and radiations from radioactive materials in the ground. All of these have the power of knocking electrons from the atoms of a gas and making it conducting.

When the leakage of charge from the leaves of the electroscope due to all these known causes is taken into account, it is found to be not quite enough to account for the actual rate of fall of the leaves. There is a little extra ionization of the air in the electroscope which cannot be due to X-Rays, ultraviolet

light, heat or radioactive radiations. This is the minute leak to which it seems necessary to assign a cosmic origin. It is assumed that electrons are knocked off some of the atoms of the gases in the electroscope by some highly penetrating, very powerful radiations which come from outer space.

These new rays are important because, coming from outer space, they may be able to tell us about their origin and about conditions at their place of origin, whether in empty space or in some star. They are also an unknown element in our environment. When X-Rays were discovered it was soon found that they had definite effects on living tissue. What are the effects of Cosmic Rays? They are undoubtedly breaking up millions of atoms in our bodies every day.

Dr. Timofeeff-Rashevsky has shown that X-Rays can speed up evolution, retard it or reverse it; that they can produce marked changes in the color, shape and size of eyes, wings, and other parts of fruit flies. Dr. Lewis Knudson has shown that proper dosage of X-Rays can increase the rate and quantity of growth of ferns, and that heavier doses can completely stop growth. What effect do cosmic rays have on growth and heredity? The answer to such questions must await a better understanding of the rays themselves.

Some of the things which we naturally wish to know about these rays that seem to come to us from outer space are: (1) Are we sure they come from outside the earth? (2) What is their penetrating power? (3) Are they waves or charged particles? (4) From which direction do they come? Let us take up these questions in order.

(1) Until about five years before the war it had been assumed that the ionization of the air was due entirely to radioactive substances in the ground. German physicists (Gockel, Bergwitz, Hess, Kolhörster) showed by carrying electroscopes up to great heights in balloons that the amount of ionization does not diminish rapidly with increasing height as we should expect if the ground is the source of the rays, but that after a certain critical height the amount of ionization actually increases. More recently Millikan and Bowen have sent up sensitive but rugged recording electroscopes in free balloons to a height of 9.5 miles, higher than anyone can ascend in an open airplane or baloon. They measured the leak of their electroscope from the time it was three miles above ground going up to the time when it was at the same level coming down and found it to be three times as

great as it would have been had the instrument been at the ground all the time. Since then the Belgian physicist Picard made his remarkable flights in the completely enclosed chamber of a balloon, measured cosmic rays at a height of 10.5 miles and found the ionization to be more than a hundred times as great as on the ground. Since the intensity increases with height it is logical to assume that the rays either are formed in the upper atmosphere or come in from space. The latter solution is pretty generally accepted because there is no evidence of atomic transformations in the upper atmosphere such as could give off the observed radiation.*

(2) The penetrating power of the rays has been measured by sinking electroscopes under the surface of lakes to find to what extent their ionizing power is diminished by measured thicknesses of water. Regener did this in Lake Geneva. Millikan, hoping to avoid any spurious effects due to radioactive materials in the water, has done it in snow-fed lakes in the Sierras and the Andes. The intensity of the rays is gradually diminished as the electroscope is lowered but it does not drop to a negligible value until very great depths are reached. Jeans estimates that the energy carried by these penetrating radiations forms about one-tenth of all the total energy which the earth receives from all the stars. Probably throughout the universe the energy of cosmic rays is more plentiful than that of light and heat.

(3) How is one to decide whether a stream of radiation is made up of charged particles or of waves? A very obvious difference is that charged particles in motion would be deflected by a magnetic field while a stream of waves would not be deflected. There is the complication, however, that waves produce their ionization by knocking electrons from atoms. These electrons move at high speed and ionize the gas. Thus waves ionize a gas largely by the secondary effect of the electrons which they liberate. The cosmic rays which are examined in the laboratory thus are always accompanied by moving particles which can be deflected by a magnetic field. It is not possible to tell whether these are the primary rays or are produced by these rays. There is, however, one test which seems to be crucial. If cosmic rays are made up of charged particles they should be very noticeably affected by the earth's magnetic field which, while it is not very

* Picard in a recent newspaper article says that his most recent data seems to indicate that at least some of the rays are produced in the upper atmosphere. A. H. Compton says his data admit that possibility.

intense, is very extensive. The results would be that charged particles would be deflected towards the magnetic poles and cosmic rays should be more intense in the neighborhood of the magnetic poles than elsewhere. Measurements have been made in arctic waters by Bothe and Kolhörster; Millikan has taken his electroscope to Churchill, Hudson Bay, the nearest settlement to the North magnetic pole; others have carried their instruments to the South magnetic pole. The evidence seems to show no greater intensity of rays at the poles than elsewhere, indicating that the rays are not charged particles and must be electromagnetic waves. However, a preliminary report of the extensive survey made by Professor A. H. Compton says that his measurements show a minimum of cosmic ray intensity at the equator and a gradually increasing value as one moves north or south from the equator, which is what might be expected if the rays consisted of charged particles. Prof. W. F. G. Swann and his colleagues have some data which corroborates this.

(4) Do these rays come from any particular celestial body or bodies or from any particular direction in the heavens? Since the sun has such a profound influence on our planet and particularly since it modifies the magnetic field of the earth in some undetermined manner, it is reasonable to suspect that this powerful radiation originates there. If it does, we should expect to find it very strong during the day and weak at night, but this is not the case. Any variation between day and night is almost negligible. There is no evidence that the presence of any celestial object overhead makes any appreciable difference in intensity.

There are three ways of estimating the direction of greatest intensity. By shielding the electroscope with heavy lead plates on all sides but one, the ionization produced by rays from that direction can be measured. It is possible to so construct a chamber (a Geiger counter) with a wire running through the middle of it, that every time a charged particle passes through the air in the chamber it starts a very brief electric current which will make a click in a telephone receiver. If two or more of these are placed along a given line the effect of a given cosmic ray should click the telephone connected with all of them practically simultaneously if the ray travels along the same line as that on which the "counters" are placed. If the ray travels in some other direction it may hit one but not the other counters. If the counters are successively placed along different lines varying

from vertical to horizontal, the direction of maximum cosmic rays will be that in which there is a maximum number of simultaneous clicks in the telephones used. The clicks, by the way, may not be set off by the cosmic rays but by some electrons which have been knocked out of atoms by these rays.

The third way of estimating their direction is by the use of a very ingenious device called the C. T. R. Wilson cloud chamber. If a mass of air standing over the surface of water (and therefore saturated with water vapor) is compressed slowly and then suddenly expanded, the cooling produced by the expansion will cause some of the water vapor to condense, forming a cloud in the chamber. Thunder clouds are formed in this way. Large masses of warm saturated (muggy) air suddenly rise by convection. In rising into the upper atmosphere they expand and cool, losing some of their moisture which forms as a cloud. It is a well known fact that drops of moisture form much more readily on particles such as dust or charged particles than they do in a space which is clear of such things, as fog forms more readily in a dirty, smoky air than in clean air. In the Wilson cloud chamber the sudden expansion is carried on a number of times until the chamber is cleared of any dust, then when the air is expanded again the clouds form on the charged particles produced by the cosmic rays and the paths of these particles can be clearly seen and photographed by the thin trail of condensed water drops which they leave in the chamber. All three methods indicate that the maximum direction of cosmic radiation is from vertically overhead and that it diminishes in the directions toward the horizon in such a way as to indicate that cosmic rays come to the earth from all directions with about uniform intensity. Those which come in at an angle with the vertical have their intensity diminished more than those which come in vertically because they must pass through a greater thickness of air.

There is not much general agreement as to the source of this highly penetrating radiation. It apparently does not come from a particular celestial body or from a particular part of the heavens such as the Milky Way. Its intensity is no greater from a part of the sky containing a myriad of stars than from other parts where stars are comparatively scarce. May we infer from this that it is not produced in the stars? But we cannot consider the possibility that millions of years ago it was produced in the stars by some process which does not now operate and

that it has been wandering around the universe ever since. There seems to be only one conclusion left if the evidence that it is not produced in the upper atmosphere is sufficiently strong: that is, that it is formed in interstellar space where the pressure and temperature are very low. This is the conclusion of Professor R. A. Millikan who, in 1923, received the Nobel prize in physics for his experimental determination of the charge on the electron. But how is it produced out in space which is practically "empty"? There is no evidence that any possible radioactive transformation can give off rays having the appropriate energy. There remains the possibility of some atomic transformations based on Einstein's conclusions that the law of the conservation of mass, and the law of the conservation of energy, are separately not valid; that matter may be destroyed provided that at the same time a suitable amount of energy is created; that matter may be changed to energy. The astronomers and astro-physicists have already found it necessary to fall back upon this to account for the long continued radiation of heat from the stars and for the long life of the sun. Jeans assumes that the stars, including our sun, are able to give off heat for so many millions of years because energy is produced inside of them by the annihilation of hydrogen atoms, one proton and one electron combining together with a tremendous release of energy. This process if it took place in the surface of stars as well as in the interior would give off penetrating rays such as cosmic rays. But Millikan says that in order to give off as much cosmic ray energy as is observed atoms would have to be annihilated at such a rate as would raise the temperature of stars much above those observed. He considers that annihilation of matter cannot be responsible for more than about one-half of one per cent of cosmic rays if any. There is also the added argument that if these rays are produced by the annihilation of matter in celestial bodies the process must also be assumed to be taking place in the sun and we should notice an increase in intensity of the rays during daylight hours due to the relative nearness of the sun to the earth as compared with the distance of other stars.

There is another atomic process in which some mass disappears and energy appears in its place, atom building. There is very strong evidence that all matter is made up of the same primordial stuff, protons and electrons. A hydrogen atom is made up of one proton and one electron; a helium atom of four

protons and four electrons. But a helium atom does not weigh four times as much as a hydrogen atom. A hydrogen atom weighs 1.008 units while a helium atom weighs 4.00 units. When four atoms of hydrogen combine to make one atom of helium 0.032 units of mass are lost, radiated away as energy in the form of waves whose energy can be calculated from an equation derived by Einstein. Millikan has found that his observations of cosmic rays indicate that they come in bands of different penetrating power and that the main band has energy comparable to that which would be given off if four hydrogen atoms were condensed into a helium atom. He accounts for some other bands on the assumption that others of the common elements of the universe are being built up from hydrogen and helium. For example, oxygen is made up of sixteen hydrogen atoms, silicon of twenty-eight, etc. Millikan found that the energy of the cosmic ray bands which he measured could be reconciled with the energy liberated when the most common elements are formed from hydrogen or helium.

Jeans assumes that the temperature of the stars is maintained by the energy liberated when electrons and protons are annihilated. Millikan assumes that electrons and protons are combining into complex molecules. How is it that these primary building stones have not been used up? Jean's opinion is that they are being used up and that the universe is "melting away into radiation." This is a modification of the old hypothesis that the universe is "running down"; that energy is becoming less and less available; that energy is becoming distributed more and more nearly uniformly throughout the universe. This process is not taking place as rapidly as would be the case if the loss of heat from celestial bodies follows the same laws as those observed on the earth, so we assume that matter (hydrogen) is being annihilated to produce more energy. The natural conclusion is that hydrogen is becoming less available and the process must ultimately stop. Millikan offers an alternative suggestion, namely, that somewhere else energy is being condensed into matter; that in the cold regions of outer space under conditions which are just as unfamiliar to us as are those in the interiors of stars, the transformation of matter into energy can be reversed and radiant energy can condense into protons and electrons. If we accept this theory we avoid the conclusion that the universe is "running down" and consider it as a system in dynamic equilibrium. Protons and electrons are forming in empty space.

These condense (liberating radiation, cosmic rays) into atoms of the various elements which gravitate towards each other and form bodies. These bodies cluster together finally forming stars. The pressure and temperature conditions in these stars become such that some protons are annihilated and heat produced which causes more radiation to go out into space. Under this theory our universe is in a state of continual change but is not running down. Atoms are being destroyed in some parts of it and built up in others. Philosophically there is a tremendous difference between the two theories; between a universe which is "running down," whose days are numbered (in very large numbers) and one which is running down at some places and building up at others and has no end.

THE BLACK HILLS SCIENCE CLUB

By Carl G. Watson

South Dakota State School of Mines, Rapid City, South Dakota

Recently there was organized in the Black Hills region of South Dakota a Black Hills Science Club. The purpose of this organization is to stimulate an interest in the various sciences and in particular to promote a study and appreciation of the natural wealth and beauty of the Black Hills. Two meetings have been held; the first at picturesque Sylvan Lake Hotel and the second at the South Dakota School of Mines located at Rapid City. The laboratories at the school were in session in the forenoon for the members to visit and thus avail themselves of the opportunity to see their former students and sons performing college tasks.

The papers that have been presented are as follows:

The Work of a Naturalist in Yellow Stone National Park, by Supt. H. R. Woodward of Hot Springs, S. D.

Synthetic Organic Chemistry by Mr. Clyde Gates of Trojan, S. D.

Black Hills Placers by Mr. L. B. Wright of Lead, S. D.

Black Hills Flora by Prof. A. C. McIntosh of Rapid City, S. D.

Prehistoric Animals by Mr. J. D. Bump of Rapid City, S. D.

The officers of the club are: President, A. W. Schmidt, Lead; Vice-President, V. L. Watkins, Sturgis; Secretary and Treasurer, Clara M. Roberts, Rapid City.

The next meeting is to be held at the Black Hills Teachers College at Spearfish, S. D.

THE CRISIS IN EDUCATION

A very vivid indication of the present crisis in education is contained in a letter just received by D. Appleton and Company, the book publishers. The letter is from a high-school teacher in an Ohio city and reads as follows: "I like the book ('Living in Our Homes' in the new Friend and Shultz 'Junior Home Economics' series) very much—so much that I want to buy a set to use in the seventh and eighth grade classes. I wish to have a dozen of these books sent C.O.D. to me. I understand the price to be 1.10. I am paying for these books myself because there is no possibility of the School Board doing so this year."

A MATHEMATICS ROOM THAT SPEAKS FOR ITSELF

By Edith L. Mossman
Garfield Junior High School, Berkeley, California

In a progressive, "up-to-date" Junior High School, there are parts of the building that people from all walks of life enjoy looking into. The art and music rooms, the science laboratories, the shops, the cooking and sewing rooms all name themselves pleasantly and adequately. Often it is easy to see where the history and geography are taught, and also the English. But where is there to be found an attractive room that introduces itself, making you feel that you'd like to have the fun of staying there a while finding out interesting things about mathematics?

No principal would think of asking the teacher of drawing, singing, science, manual training, cooking or sewing to teach in just any room here or there. "Why of course not," you say, "there is too much necessary material and equipment or apparatus that cannot be carried about." But it is supposed that for mathematics only blackboards with chalk and erasers, and paper and pencils,—perhaps rulers and dividers, are needed. That subject, therefore, can be taught all right anywhere that a room happens to be free.

As it has been done and still is usually done there could be no argument here. But there will soon be an awakening that will make it just as impossible for a mathematics instructor to carry about the necessities for good teaching as it is for an instructor in art or science.

In the first place, *every* school room should be kept neat and tidy, and also really attractive. It is unpardonable to allow trash on the floor or in the desks—as unpardonable as it would be in the living room at home. What is thought of the housewife who has one shade high up, another quite low, a third somewhere between, and one or more crooked? In the school rooms where pupils and teachers live for about seven hours, five days a week, do not the same standards of good taste apply as in the homes?

If in the evening or on Saturday or Sunday, a lady would not feel satisfied with flowers in a cracked or dirty vase or in one of the wrong color or shape, then why should she allow such a thing during the day with the children? Blackboards partly erased or showing scribbly, careless work, posters or notices

tacked up out of line, with no thought of appearance should offend the eye of both pupil and teacher. Boys and girls are definitely uplifted in soul by a lovely growing fern or begonia, or a beautiful bunch of glossy greens or of pepper berries.

In the Lincoln Experimental School at Columbia, are wonderful mural paintings of great mathematicians. Probably there are not many places where this is possible. But good copies in color, have been made. These framed and hung low are a splendid start in gaining the desired "atmosphere." Not only did the pupils from my own classes pore over these pictures and the descriptions printed below, but they told other boys and girls about them. So every once in a while one or more pupils whose names and faces I do not know, come in asking permission to study the pictures.

A bulletin board adds much to the stirring up of alertness in noticing how big a part mathematics plays in the world to-day. This in turn leads to increased interest and to an appreciation that has its refining, cultural effect. Some of the newspaper clippings and pictures brought in will receive but a moment's attention. Others will accomplish a great deal not only in that particular group but in all the classes of the day.

Then besides the bulletin board there must be a table or a shelf for helpful, awakening magazines and books. And too, there should be slide rules, a sphere that falls apart into pyramids, a circle that separates into triangles, a prism and a pyramid of the same altitude and diameter, a cylinder and cone of the same dimensions, an abacus. . . . anything and everything of the mathematical world that it is possible to secure for the boys and girls to touch and handle and talk about and experiment with.

There are always those pupils who at first and always set down their problems neatly, plainly. There are others who scribble and scrawl, presenting papers that are disgracefully untidy. Accepting such work allows the fixing of careless habits of thinking which necessarily bring undesirable results of several kinds.

Two years ago it seemed unusually difficult to present the situation so that *all* in my classes should feel it worth while to prepare creditable daily papers. One day an assignment was given calling for a paragraph or two, or an outline on "An Excellent Paper." From this assignment teacher and pupils together formulated the following:

AN EXCELLENT PAPER

1. Rules of an educated world observed.
   (a) No scribbling or crowding
   (b) Correct forms in:
       Capitalization
       Spelling
       Punctuation
   (c) Best arrangement for plainness.
2. Estimate. (*First.*)
   (a) Avoid absurd answer
   (b) Think all through before using pencil
3. Drawing if possible
4. Correct reasoning and correct answer
5. Good labeling
6. Check
7. Solution by another method

This is beautifully printed on a piece of tag board eighteen inches by twenty-six inches, the work being done by a very talented young Japanese girl. The chart has hung in the class room ever since and has many, many times proved to be of much value.

Only the first point deals with the appearance of the paper. The six points following accentuate other necessities for all-round, solid growth mathematically. This silent influence from that spot between two large windows has been very evident again and again.

Another attractive chart of same size and same style of lettering, hanging in the next "between window" space has been a great help. Pupils often ask why all should be compelled to study so much mathematics. Animated discussions in the different classes were formulated or "boiled down" to this:

DESIRABLE HABITS TO BE FORMED OR STRENGTHENED IN A MATHEMATICS COURSE

1. Neatness
2. Independent thinking
3. Following directions exactly
4. Honesty
5. Clear, logical thinking
6. Appreciation of what mathematicians have done for our comfort and convenience
7. Unwillingness to let a mistake go uncorrected
8. Keenness to detect absurdity of an answer
9. Reverence

One day about two years ago, I gave to all my classes from L7 through H9, the same assignment: "Earliest mathematics—

nothing later than 1700 B.C." A facsimile of the *Rhind Papyrus* had been borrowed from the University of California library. Later, I sent to London purchasing one that is kept in the room and often used. Just recently I ordered one with translations being put out by the Open Court Publishing Co. of Chicago. Also at that time there were in the room three copies of *Number Stories of Long Ago* by David Eugene Smith, and several histories of mathematics. Then, too, other sources of information were listed, such as encyclopedias, the Lincoln Library, etc.

The result was tremendously gratifying. Such quantities of good material were brought in, such clear, lively reports were given, such eager attention prevailed. And also, far-reaching effects were very evident. Quite a number who had before been careless and lackadaisical, woke up and thereafter gave much better effort in the preparation of the regular mathematical work.

From this lesson the following chart appeared:

EARLIEST MATHEMATICS
? — 1700 B.C.
4000 or more years ago.

First attempts to count:
(a) Egypt
(b) China
(c) Babylonia

Earliest means of counting:
10 fingers and toes

Records on:—Clay tablets . . . Papyrus

Egypt	Babylonia	China
1. Pyramids	1. Stars	1. Trading
2. Nile overflow		2. Abacus

Oldest book on mathematics in existence
"The Rhind Papyrus"
Ahmes—Egyptian Scribe—1700 B.C.
British Museum

The next term there were reports on the "Brilliant Greek Period" and another chart was prepared. Since then two more have been finished, together called "Mathematical Contributions from: I. The Romans. II. The Japanese. III. The Maya. IV. The Hindus. V. The Arabs. The coming term we expect to produce two more: (1) Modern Mathematics. (2) Living mathematicians."

Another item to be presented in a description of our effort to bring into being a "really, truly" mathematics room that should attractively invite all to come in and enjoy what is found there,

is the making of posters, busts, and models. I offered the suggestion for the first time last term, saying very little about it, giving only a few words about possibilities. The result was quite overwhelming: more than two hundred from my five classes. A very small number was not worthy of attention, but nearly all were really good, many were more or less original, while several were truly remarkable.

About twenty of them used the idea "Before Math—After Math" in one way or another. For instance, one had pictures of a peasant girl using a sickle in a grain field and of a modern reaper in the wheat lands of Dakota. Another way of using the same idea was shown in "Mathematics Needed to Bring about Progress in Transportation." Pictures were presented of earliest man on foot, then one riding a horse, and after that the use of primitive carts, followed by lumber wagons, then by steam locomotives, automobiles, and airplanes. Also there were old dugouts, canoes, sailing vessels, and modern ocean liners.

A Japanese girl sketched a Japanese policeman holding a signal which said:

Stop!
Check!
O. K.?
Go!

Several made neat, artistic copies of early numerals from the Chinese, Japanese, Babylonian, and Mayan. A very talented little L7th boy made splendid copies of "Ahmes and the Priest at the Temple Gate," and of "Archimedes."

A H9th boy drew with excellent perspective a corridor with doors on each side. On the doors appeared the names: Radio, Aeronautics, Chemistry, Physics, Astronomy, Surveying, Transportation, Mechanics, Architecture, Mining, Banking. In the foreground was a large key and the words: "Mathematics, the Master Key." Five other pupils used the idea in slightly varying ways.

A ninth grade girl who is very clever indeed with brush and pencil gave part of a span of suspension bridge with a ship near at hand, and sky-scrapers in the distance. The words were: "Not This without Math." The arrangement of the picture and its lettering and the coloring are most artistic.

In a H8th class, a Z section boy who is not at all gifted in art, produced an original poster that attracted some attention. Across the bottom of the paper was a blue space named "Times'

Waters." Rising from it at the left was the cliff of the "*Unknown*" and at the right, the cliff of "*Success.*" High up above the waters, a narrow foot bridge extended across carrying along the figures: 1 2 3 4 5 6 7 8 9 0. It was named "Math's Bridge."

Two of the most attractive ones were rather fanciful, one the work of a boy and the other of a girl, each of whom has much artistic ability. The coloring and arrangement were beautiful.

One was of a fine looking young man standing against a lovely tree and gazing out and up into space as if dreaming great dreams. A little distance out in the air there appeared glimpses of airships, radios, etc. 'Tis named "Day Dreams of Mathematical Results."

The other was of a pretty girl dropping pebbles in the water, watching the ever widening circles formed by each. Underneath was printed: As the ripples from a pebble dropped into the water will travel in ever widening circles across the whole surface of the pool, so will an idea, however vague, catch hold of a man's mind and no one can tell to what it may lead. Mathematics, one of the most important branches of science was started and has grown in just that way.

Many more interesting ones could be described were there time and space available. The following copied from them will allow the imagination to picture something of what they were like:

1. The Work of Math.
2. Math. a Key to Success
3. The World Needs Math.
4. Math. Mastered This
5. Products of Math.
6. If No Math.—No Cars
7. If No Math.—No Engineering
8. If No Math.—No Building
9. If No Math.—No Radio
10. Panama Canal—Example of Math.
11. Imagine the World without Math.
12. Men and Math. Will Bring This True
13. An Achievement of Math.
14. Math.—The Corner Stone of Success
15. Math in Ancient Times and Math in Modern Times
16. Mathematical Precision
17. Math's Old Bridge
    Math's Modern Type
18. From This (Auto of 1894) to This (Auto of 1932)
    Impossible without Math.
19. Math. a Gate to Success

20. Surrounded by Math.
21. Result of Higher Mathematics
22. Math. Made the Change
23. Up in Mathematics (Zeppelin and Monoplanes)
24. These figures are like Washington
    And I will tell you why—
    It really is exactly true
    That figures never lie.

When putting up posters in the room we were very careful to use only a few at a time, and to take much thought in placing those chosen. The art teachers highly commended the result.

A number of the pupils from different classes brought busts, plaques and models. Archimedes and Euclid appeared several times in both modeline and in soap. Two girls brought good work done in mashed potato.

One of the most interesting contributions was a perfect model of the Archimedean screw. It was about twelve inches long—Large enough to show its parts clearly. And it worked! Again and again during the rest of the term, groups stood around it watching the water being lifted to the higher level, and talking about the man who more than two thousand years ago was able to give this invention to the world.

Much could be said, too, about the excellence and the variety of booklets and charts brought in for the classes to enjoy and to discuss.

It is very valuable to leave the work of each class on the board for the next group to see. It matters not whether this group is of a higher or lower grade or of higher or lower intellectual possibilities. Also it is decidedly worth while to have one place on the board in which the *first* problem of the lesson always appears, the others following to the right in regular order. When the pupil erases the work of the preceding class very perfectly, and puts on his own name, the number of his problem, and the solution very neatly, he himself gains something as do also those of his own and the following class who see his work.

It is well every once in a while to give something from number recreations—some easy thing, interesting or catchy—to *all* the classes, letting each one know what the others do with it. This and the posters and bulletin board items, together with the glimpse on the board of the daily work of each other help to build up a stronger bond for the mathematics room and the various phases of that subject.

It must not be supposed that much time was used for posters,

history of mathematics, clippings, etc. That would be impossible since so many topics must be studied each term in order to be ready for the next term's course of study. But the very little time spent on these interest aids has given to the room an "atmosphere" that inspires to better, faster, happier work on the requirements.

Many of the pupils as well as quite a number of the parents have exclaimed with pleasure at the appearance of the room, the latter saying that they wished they could come and join us in such surroundings. It will not be long until teachers feel it a necessity to have a room that at first sight calls out: "Here is a place to *enjoy* learning things in mathematics."

ASSEMBLY PROGRAM ON THE ECLIPSE OF THE SUN

By Clara B. Thomas
Lexington School, No. 34, Rochester, New York

As a result of a two-day science lesson on the sun and moon, the class decided to give a short program in a morning assembly. They wanted to show by means of pictures and talks how the eclipse of the sun took place in August.

A brother of one of the pupils had taken photographs of the eclipse at regular intervals. One of the children wanted to draw reproductions of them and show them in the assembly. Then someone suggested a device which would illustrate just which path the moon took during the eclipse.

Four little talks were prepared and given. During the fourth one, two boys demonstrated how the eclipse took place. A large cardboard was held on a low table. A large hole had been cut out to represent the sun and yellow cloth was pasted over this. An electric bulb was held back of this. The moon, a piece of cardboard, suspended by a wire, was held so that it slowly passed in front of the sun. The little talks given are as follows:

Queer Ideas of the Moon

Many children and grown-ups too, have queer ideas of the moon. Often times when you look up at the moon you will see a figure that looks like a man and again you will see something that looks like a woman. Many legends have been told about the man in the moon. I am going to tell you about some. There is a legend of a beautiful fairy queen that sits on a golden throne in the moon. There is another one of a rabbit's kindness to the Buddha and he was set on top of the moon. The last one was one that

an Indian told. It was about a woman who kept asking when the world was going to come to an end. Therefore, she was sent to the moon. Of course, you know these are not true. I am sure you would like to study about the moon.

by PHYLLIS AXON, Sixth Grade A

THE MOON'S PHASES

Every 29½ days the moon makes a complete trip around the earth. When it is directly between the sun and the earth, its dark side is toward us and is entirely invisible. As the moon revolves a cresent appears. This grows larger until it is finally gone from sight. These are called the phases of the moon.

People who live by the sea know about the tides. At full tide, the water is drawn back. This is called flood tide. When the moon shifts its position, the water flows out and it is called ebb tide.

by CLARENCE TEMPLETON, Seventh Grade B

THE SIZE OF THE MOON, EARTH AND SUN

The moon appears to be about the same size as the sun. However, it is really only about one-fourth the size of the earth. The diameter of the sun is about 110 times that of the earth. The moon's diameter is about 2,160 miles, while the earth's is about 8,000 and that of the sun 864,390 miles. The moon is not as far from us as the sun. If it were, we would not be able to see it at all.

by EDWARD MEYER, Sixth Grade A

THE ECLIPSE OF THE SUN

Most of you saw the eclipse of the sun August 31, 1932, when the moon passed between the sun and the earth. We have been studying the sun and the moon and will show you how it would look at a total eclipse. Pretend today is an eclipse of the sun. Get your smoked glass ready. At first, just a bit of the sun is covered where the moon is starting to cross the path of the sun when at last it will appear at its smallest. Then there will be strange shadows on the trees, streets and houses. Gradually it disappears and the eclipse is over.

by DONALD BENTHAM, Sixth Grade A

FIND EGYPTIAN QUARRIES LOST 35 CENTURIES

Egyptian quarries, lost 35 centuries, have been discovered by a Cairo museum official in the desert west of the Nile, near Abu-Simbel.

The quarries contain diorite, a gray colored rock, Amethystine quartz is present in the rock, indicating that the ancient Egyptians may have used these quarries as a source of their much-prized amethyst.

Discovery of the quarries follows an earlier, accidental discovery made by Sir Charles Spinks, inspector general of the Egyptian army. While on western desert patrol he found cairns containing stone tablets and tables of offerings. Museum officials became interested and, investigating the region, discovered the Egyptian quarries of rock and gem stones.—*Science Service.*

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Twenty-Third Meeting

Massachusetts Institute of Technology
Cambridge, Massachusetts
Saturday, February 4, 1933

MORNING PROGRAM
Room 10–275

9:15 Meeting of the Executive Committee.
9:30 Business Meeting.
9:45 Reports of Committees.
10:00 Address of Welcome: Prof. J. C. Slater, Head of Department of Physics, M. I. T.
10:15 Discussion: "The Content of the Preparatory Course in Physics." Committee on College Entrance Requirements in charge. Mr. Burton L. Cushing, East Boston High School, Chairman.
Speakers: Prof. N. Henry Black, Harvard University.
Mr. J. M. Arthur, St. Mark's School, Southboro.
Mr. Fred R. Miller, English High School, Boston.
11:15 Address: "The Measurement of Color." Prof. Arthur C. Hardy, M. I. T. Prof. Hardy will demonstrate the new photo-electric color analyzer.
12:00 Address: "Certain Fundamentals of Electrical Communication." Mr. J. W. Horton of the General Radio Company.
12:45 Luncheon at the Walker Memorial. Price, seventy-five cents.

AFTERNOON PROGRAM
Room 10–250

Joint Meeting with the New England Section of the American Physical Society

2:00–3:30 Colloquium on Nuclear Physics. Speakers:
Dr. M. A. Tuve, Department of Terrestrial Magnetism, Carnegie Institute of Washington. "Recent Experimental Developments in Nuclear Physics."
Dr. R. J. Van de Graaff, M. I. T., in a demonstration of a one and a half million volt Electrostatic Generator.
3:30–4:30 "The Sun as a Physical Laboratory." Dr. D. H. Menzel, Harvard Observatory.

The George Eastman Laboratory of Physics will be open for inspection between 9 A.M. and 1 P.M.

The mailing list is being revised. If there is any error on the enclosed slip please notify the Secretary.

Progressive teachers belong to professional organizations. Get a friend to join with us for mutual profit.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, LOUIS A. WENDELSTEIN, High School, Everett, Mass.
Vice-President, HOLLIS D. HATCH, English High School, Boston, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, WILLIAM F. RICE, Jamaica Plain High School, Boston, Mass.

Business Meeting

The following were elected to active membership,

Miss Minne Belle Brewer, The Buckingham School, 10 Buckingham St., Cambridge, Mass.

Mr. Dennis C. Haley, Teachers College of the City of Boston.

Mr. George Durgin, State Normal School, Bridgewater, Mass., was changed from active to associate membership.

President Wendelstein expressed the thanks of our Association to the Massachusetts Institute of Technology for their hospitality in entertaining us for this meeting and also our appreciation of the courtesy of the New England Section of the American Physical Society in arranging for the joint meeting in the afternoon.

REPORT OF NEW APPARATUS COMMITTEE

John C. Packard, *Chairman, Brookline High School*

Mr. Packard showed a rod of artificial amber, an improved form of automatic hygrometer and a thermometer with a red liquid making it very easily read.

Mr. Fletcher and Mr. Johnson of the North High School, Worcester presented some very ingenious experiments with vibrating strings.

REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS

C. W. Staples, *Chairman, Chelsea High School*

BOOKS

"National Physical Laboratory Report for the Year 1931." 313 pp., 54 fig. London 1932.

"Electrons and Waves," by H. Stanley Allen. 60 fig. 336 pp. London 1932 Macmillan & Company. $2.50. Occupies mean position between technical treatises and books of popular character. Contains most recent views of electrical constitution of matter and nature of radiation. Chapters on theory of relativity, quantum theory, X-rays, atomic structure, radioactivity, crystal analysis, wave theories of de Broglie and Schrödinger, and the light quantum.

"Experimental Television," by A. Frederick Collins, Boston, 1932. 313 pages. A series of simple experiments with television apparatus; also how to make a complete home television transmitter and receiver.

"Radio Engineering," by Frederick E. Terman, New York, 1932. 688 pp.

"Vibration Prevention in Engineering," Arthur L. Kimball, 1932. 145 pp.

"Aviation and the Aerodrome," by Dale H. Angley Lewis, London, 1932. 168 pp.

"Combustion, a Reference Book on Theory and Practice," 3rd Edition, American Gas Association, New York, 1932. 208 plates. Relates to gas burners and heaters.

"The Interpretation of the Atom" by Frederick Soddy. Putnam's Sons New York City 1932. 355 pp. 75 fig. $5.00. Part I. The Radioactive Elements and Isotopes. Part II. General Progress of Atomic Chemistry.

NEW PERIODICALS

Journal of Chemical Physics.—A new monthly journal inaugurated by the American Institute of Physics begins its career with January, 1933. It fills a field not hitherto occupied; namely, that embracing papers on the border-line of Physics and Chemistry. Special subjects to be included are thermodynamics, solutions, surface phenomena, and heterogeneous catalysis, molecular structure, electric moments of molecules, photochemistry, statistical mechanics and its application to kinetics of chemical reactions; crystals and the solid state.

Dr. Harold Urey of Columbia University is managing editor, and 22 prominent men form the editorial board. Subscription rate, $10.00.

The American Institute of Physics announces that after January 1, it will publish in improved and enlarged form *The Review of Scientific Instruments* with *Physics News and Views*. This will be free to subscribers to *Journal of Chemical Physics* and other physical journals in this country, and to all members of the American Physical Society. To others, $4.00 per year.

Address of American Institute of Physics is: 11 East 28th Street, New York.

REFERENCES TO PERIODICAL LITERATURE

Aeronautics

"Steam Takes Wings." *Popular Mechanics*, December 1932, p. 857.

"Air-minded Japan," by A. J. Milling Jones. *Asia*, February, 1933.

Alloys

"Gems that Harden Copper" (Beryllium-copper alloy). *Technology Review*, January 1933, p. 146.

"What is the Lightest Metal?" (Possibilities of Alloys of Magnesium) by G. Edward Pendray. *Popular Mechanics*, December 1932, p. 875.

"Selenium Steel." *Literary Digest*, December 31, 1932, p. 21.

Apparatus

"The Physical Society's Exhibition" (A comprehensive display of scientific apparatus) (Illustrated). *Electrical Review*, December 30, 1932, p. 955.

Atmosphere

"Unconquered Mt. Everest" (A new attempt) Robert Foran. *Travel*, January 1933, p. 9.

Astrophysics

"The Portsmouth Works" (Mound-builders structure an astronomical temple) S. Hagar. *Popular Astronomy*, January 1933, 0. 2.

"The Size of Meteors" (The Leonids of 1932). William H. Pickering. *Popular Astronomy*, January 1933, p. 22.

Astrophysical Journal, January 1933. Several articles on spectroscopy.

Electroplating

"New Platinum Plating Process." *Brass World*, December 1932, p. 250.

Heat

"Automatic Temperature Control Apparatus" (Illustrated). *Engineering*, December 20, 1932, p. 764.

"An Improved Boiling-Point Apparatus." Herbert L. Davis, *Journal Chemical Education*, January, 1933. p. 47.

"Turbine Efficiencies Raised by Detail Improvements." *Power*, January 1933, p. 13.

Historical Physics

"Mr. Edison's Phonograph." R. D. Darrell, *Sewanee Review*, January-March, 1933, p. 91.

"L'inventore del 'Coherer,' Temistocle Calzecchi-Onesti." *Illustrazione Italiana*, December 25, 1932, p. 939.

"The Origin of the Lathe." L. L. Thwing, *Technology Review*, January 1933, p. 134.

Invisible Radiations

"A Geographic Study of Cosmic Rays." Prof. Arthur H. Compton, *Scientific Monthly*, January 1933, p. 55.

"Cosmic Rays, Experiment and Conjecture." Alexander W. Stein, *Journal of Chemical Education*, January 1933, p. 24.

"Measurement of X-ray Emission Wave-Lengths by Means of the Ruled Grating." Witmer & Cork, *Physical Review*, December 15, 1932, p. 743. (Numerous other articles of interest in same issue.)

"Splitting Atoms with Artificial Radium Rays." *Popular Mechanics*, December 1932, p. 896.

Light

"Using Paint as Light." *The Painters' Magazine*, January 1933, p. 12.

Mechanics

"World's Biggest Stage is Marvel of Mechanics." (Radio City Music Hall, Rockefeller Center, New York City.) *Popular Science*, February 1933, p. 16.

"Centrifugal Purification of Oil." *Mechanical World and Engineering Record*, Friday, December 30, 1932, p. 632.

Meteorology

"Well-Like Gigantic Ant-Hill Gathers Water from Air." *Popular Mechanics*, December 1932, p. 868.

Radio and Radio Devices

"Ear-Phones in Istanbul." Memdouh M. Mazlowm, *Asia*, February 1933, p. 85.

"Crewless Lightship is New 'Flying Duchman'." *Popular Mechanics*, December 1932, p. 856.

"The Golden Graves of Cocle" (Treasure-hunting by radio). *Popular Mechanics*, December 1932, p. 954.

Testing Materials and Measurement

"The Character of Cast Iron" (Study of Elasticity and Plasticity). A. C. Vivian, *Mechanical World and Engineering Record*, December 30, 1932, p. 261.

"Some Magnitudes." Prof. Ingo W. D. Hacke, *Scientific Monthly*, January 1933, p. 55.

Transportation

"Russia Too has a Railroad Problem." William C. White, *Asia*, February 1933, p. 73.

"T-6, The Latest Giant of the Sea." D. N. Glass, *Popular Mechanics*, December 1932, p. 881.

REPORT OF CURRENT EVENTS COMMITTEE

J. P. Brennan, *Chairman, Somerville High School*

Turkey has adopted the metric system. In connection with this fact it is interesting to note that certain athletic associations here in the United States are opposing the use of the metric system in athletic meets. The reason for this opposition is that the present records expressed in yards and miles would go by the board. It seems hard for the protestants to understand that the record for the one hundred yard dash, for instance, would still stand as the record for that distance even though the new distance would be one hundred meters.

In an address delivered before the Franklin Institute of Philadelphia,

Dr. Lewis Koller declared that some air is more beneficial than other air not so much because it is free from dust and smoke, but because it has been ionized. The ionization of the air is probably due to radium, x-rays, cosmic rays, ultra-violet rays, lightning and other causes. The air indoors is less likely to be ionized since these causes are rarely present indoors. Dr. Koller's views seem to be supported by the work of Professor Dessaiver of Frankfort who has been treating the sick with various concentrations of ions. It is said that excellent results have been obtained in cases of certain inflammatory diseases. It seems as though the ventilation engineers will have to include an ionizing apparatus in their air conditioners.

The German State Railroad has developed a streamlined railroad car that bids fair to compete successfully with airplane transportation. The new vehicle is an articulated car mounted on three trucks. It is 137 feet long and has a capacity of 102 passengers together with a refreshment room, bar, two washrooms and a baggage compartment. At each end of the car is a 410 horsepower Maybach-Diesel engine which drives an electric generator. The current is supplied to motors carried on the central truck. The 178 miles between Hamburg and Berlin were covered in 2 hours and 20 minutes, making an average speed of well over 70 miles per hour. It is said that in private runs more than 100 miles per hour have been made.

Everybody is familiar with the scheme of introducing water vapor with the gasoline vapor into the cylinders of the automobile engine to bring about more economical consumption of fuel. This idea is now being applied to generate steam in a new and more efficient way. The boiler is really the compression chamber of the engine which is a gas turbine. Gas and air are admitted and then ignited. The pressure within the turbine is thus increased about 5.5 times that of the explosive mixture. The power generated is used only to make the turbine drive the compressor. By far the larger amount of heat produced is used to generate steam.

Prof. J. C. Slater, Head of the Department of Physics welcomed us in behalf of the Massachusetts Institute of Technology. He spoke of the significance of a joint meeting of these two groups of physicists and invited us to make a thorough inspection of the new George Eastmen Laboratory of Physics.

The discussion of "The Content of the Preparatory Course in Physics" was opened by Mr. Burton L. Cushing, East Boston High School, Chairman of the Committee on College Entrance Requirements. He explained that at our December 1932 meeting it was voted to spend about an hour at this meeting in discussing the content and time allowance of the college preparatory Physics course. Certain members were invited to express their personal views on the subject. They were chosen as representing the colleges, the private preparatory schools, the public High Schools and the College Entrance Examination Board readers. These four speakers and the committee on College Entrance Requirements are to meet before the April meeting of the Association and make definite suggestions to be voted on at that meeting.

A summary of the remarks by the several speakers follows.

PROF. N. HENRY BLACK, *Harvard University*

The few words which I shall say on the subject of the proposed revision of the content of the Physics courses are my own personal opinions and in no way represent those of the department of physics at Harvard University. In fact I am quite certain that the department feels that the

physics teachers in the secondary schools of this country know better what can be taught and should be taught than any group of college teachers. But we always stand ready to coöperate in any way possible to get more physics and better physics taught in both school and college.

Now as to these proposals received from the Association of Science Teachers of the Middle States and Maryland, I do not find myself in sympathy with these specific recommendations. For some years to come we cannot get our students in American High Schools to study physics for more than one year. In this one year I believe we should give the student a *carefully selected survey* of the whole field of physics. From time to time we surely need to take account of stock and revise our contents of such a one-year course in the light of the needs of our pupils and the state of the science. In these days we also have to plan carefully what we can do with the equipment already on hand and available.

This proposal resembles in some ways the methods now used in England for the School Certificate Examinations but conditions are so different in this country where we usually have but one year instead of two or three years for physics that I would hesitate a long while before recommending this change.

Your committee has proposed two different courses in physics; one a more qualitative course with considerably less mathematical work than is now required for the College Entrance Examination. This seems to me to put physics on the general science-level. It is a pity to drop what little mathematics we have in our present course which is really only a little applied arithmetic. The other course requires two years to cover the present mathematics requirements. My own experience shows that two years is not required to cover thoroughly the present College Board requirement and a good deal more, *provided* we have six periods a week, adequate equipment for a demonstration and laboratory work and students trained to use arithmetic, algebra and geometry. But the boys and girls must work persistently and the teacher must know his job.

I have long hoped we could have a second year devoted to physics in the schools. But when it comes to a choice between two years of physics or a year of physics *and* a year of chemistry, I would favor the two sciences. It seems to me that it is quite unlikely that we can obtain credit for doing in two years what the best schools now do in one year.

In considering any such revision as this I am sure you will agree with me that we must have a committee representing the whole country. We may also be guided by the current practice in our best schools where our physics teachers have better opportunities for trying out new methods. In other words our College Board Definitions should follow current practice in the more progressive secondary schools.

Mr. J. M. Arthur, *St. Mark's School, Southboro, Massachusetts*

With the primary proposition that is given as the sense of the last meeting of this association, namely; that the number of topics treated in the course in physics should not be reduced, I am in hearty agreement, but as to the second proposition that we have a two-year course of "minor" and "major" physics, respectively, I am not so enthusiastic. On two or three counts I see serious objections to any two-year course in our science and particular objections that apply to such an "easy-hard" combination as is proposed.

The first of these objections comes from the fact that the curriculum of the secondary school is now so crowded that it would be useless to ask headmasters and principals to arrange for a second year in any one science.

Then in fairness to the two other sciences, chemistry and biology, or other life-science, which, with physics, make up the usual trio of sciences of college preparatory grade in our secondary schools, we must be ready to grant them the same two-year privilege. If you talk with teachers in these fields you will hear the same lament that comes from us,—the call for more time to properly cover the subject. Speaking for chemistry, I can say that this call has a right to be heard. The intrusion of our own science into the field of chemistry by the immense importance nowadays of the electron theory, the necessity of linking the old atomic theory with modern electronic concepts and tying them both together with the theory of ions and the complex symbolism of the ionic equation have greatly increased the difficulty of that subject in both school and college. So much has this affected prep-school chemistry that I confidently assert that a proper understanding of the subject is beyond the reach of the average college-prep student before his senior year and then only if preceded by year's course in physics. Just now, at the half-way point in the year, in my own work in chemistry, I have not quite completed the theoretical foundation that is necessary for a proper understanding of chemical phenomena as now explained.

This may seem rank heresy, spoken in a meeting of physics teachers; but it is not done in that spirit. It is rather a plea that we work toward making physics a one-year foundation for all further science courses; for only in this way can it best serve itself and them.

As a final objection to the two-year plan as suggested I would present an imaginary picture of the reactions of the students to it. We may fairly assume that most if not all of the students who take the first-year course will be attracted to the science and will enroll for the second year. The disillusionment, for most of them, will be a calamity. From the third year on I would prophesy that only the first-year course will have enough students to make it worth while to carry as an item in the curriculum.

I believe we must attack the problem by carefully examining our present course and trimming it to fit the winds of the present. To see what I would do single-handed in such a trimming I have made in the past few days a little study of the present Board syllabus. As you know the items vary widely in importance. Some are innocuous and others are packed with dynamite as, for example, "Ohm's Law" which has to bear the responsibility for half the topic, "Current Electricity," in the minds of the examiners, at least. Yet I was unable to pick any single item for exclusion, —even the minor items seemed necessary for a logical presentation of the subject. On the contrary, it is quite obvious that the topic of Electricity is inadequate, in one particular at least, to fit present day demands,—it has no mention of The Vacuum Tube. In fact, although the syllabus is only ten years old it actually "dates" somewhere in the last quarter of the past century,—the most modern electrical devices that are mentioned being the telephone and the transformer. Of the great electrical developments of the past half-century we may properly omit the x-ray and radioactivity but we surely cannot put off much longer some study of the vacuum tube as used in radio.

Then for more light on the matter I checked the Board examiners as they performed in the June exams. to see how they regarded the various topics in importance. From my own records over a stretch of more than ten years I find that, in round numbers, it has required the following easily remembered periods to cover the syllabus;—Mechanics, 10 weeks; Sound, 2; Heat, 4; Light, 4; Magnetism and Electricity, 8. The examiners have agreed with this time allotment for all topics except in the last where they have occasionally failed to give sufficient recognition. Their questions

gave no satisfactory indication of items that might be omitted; the ones that were apparently slighted being actually of minor importance in their respective topics. There was, however, a decided preference for mechanics and in certain years unnecessarily difficult problems involving absolute units.

It would seem that we might profitably reduce the content of our Mechanics syllabus,—certainly the emphasis that is given to it might be decreased, in order to make room for the necessary increase in Electricity; and our examiners might, even with the present syllabus, see that this latter topic receives more consideration than has been the rule in the past.

MR. FRED R. MILLER, *English High School, Boston*

Forty years ago, before my time, and before the time of most of us, high school physics instruction, and especially college entrance physics, was in confusion. It was put on its feet by the Harvard Descriptive List and the Hall and Bergen Text Book of Physics. For a number of years thereafter things went well. Several good text books were written and two of three laboratory manuals. The subject grew, but rather slowly, so that there was no difficulty in making adjustments as required. But in recent years it has completely outgrown the time allotment. The syllabus now by actual statement or by implication contains 1½ years' work, and we are obliged to dash from one topic to another without adequate time to teach anything effectively. Leisure is needed and we have none of it. There is no question that something should be done about it. But what?

The suggestion of the Maryland Association is not sound, for the reason that it omits one or more so called major topics. In their Group IV, for example, it becomes possible to take a course in physics in which the subject of electricity is not even mentioned.

The other suggestion, made by this Association, that the course be made to cover two years, should not be made without careful consideration. I do not think the argument that physics should have two units because French and German are allowed a minimum of two units is valid. It is a recognised fact that one year of a language gets a pupil nowhere, and if not followed by a second year is practically lost. This is not true of physics. In one year of physics a new world is opened up to the student. He probably remembers more of this course than of any other one year course in school. I have a feeling that one of the reasons for urging two years of physics is to *make* more pupils take it, or rather to increase the number of pupil hours and thus combat the falling off that is said to be the trend in physics. I feel that if the pressure of too many topics were reduced, so that he teacher could have time to go more slowly, the work would be more attractive and pupils would flock into it without urging or forcing. This of course, assumes that the teacher has good sense and is willing to use this extra time in making the work more interesting. Many schools have a course of this kind, of non-college grade, which is thoroughly enjoyed by both teacher and pupils. Even low grade pupils work hard in such a course, and advertise the course to their friends. In similar manner, what we need in the college prep. course is less pressure. We haven't time to make it interesting.

While a second year of college prep. physics might be desirable if it could be brought about, there are several points that it would be well to examine closely. If two units were allowed, the colleges would certainly expect a corresponding increase in content, which would increase and possibly double the syllabus and the number of experiments required, and the pressure would be as great as it is now. The colleges would not allow an extra unit unless we carried the pupil farther and covered part of the

work now done in freshman physics. Our boys would, however, still be high school boys, and we know that they have a hard enough time doing freshman physics in their freshman year. Furthermore there is no text book suitable for such a course; and suitable laboratory experiments would involve considerable expense for equipment if the work were to be done in a manner acceptable to the colleges as taking the place of freshman physics. A second year of *non*-college physics would be desirable, and could be managed with our present text books and equipment, but not so a second year of college prep. physics.

It might be that after careful study a committee of physics teachers and college representatives, say a College Board Committee, could work out satisfactory details for such a course. After this was done, let us see what the results might possibly be.

1st. The course recommended might be, 1st year, Mechanics and Heat, with a one unit examination at the end, content to include considerably more than at present. 2nd year, Light, Sound and Electricity, with another unit exam. at the end. Probable result: most schools would present only one group and take one unit.

2nd. The course recommended might consist, 1st year, of a once over of the entire subject, not very mathematical, with a one unit exam. at the end. 2nd year, rreview and more advanced work with a harder one unit exam. at the end. Probable result: most schools would take the elementary exam. and one unit only.

3rd. The course might be a two unit course consisting, say 1st year of Mechanics, Heat, Light and Sound with no exam. and no unit. 2nd year, Electricity and more advanced work in all topics with a two unit exam. at the end. Probable result: most students would take chemistry instead.

4th. If chemistry were also made a two unit subject, most students would choose between physics and chemistry but would not take both. Most schools (except the largest ones) could not or would not stand the expense of two years of both subjects.

What is needed is not a second year of physics or a second year of chemistry, but rather a reduction of the required material in both physics and chemistry, so that we can give students a comfortable, profitable, non-speed course in each subject. Then *two* of the fifteen units now required can be in science, which is as large a proportion as we have any right to demand. As a matter of fact these units are possible now. What we want is reduced content.

MR. HOMER W. LESOURD, *Milton Academy*

If there are pupils in a class who expect to take the physics examination of the College Entrance Examination Board the teacher of physics should become acquainted with the syllabus of that board but it is unwise to allow the course to be dominated by such a syllabus. To cram pupils with facts, principles and formulas as indicated in the syllabus in order to obtain satisfactory results in college entrance examinations is the surest way to develop a lasting distaste for the subject in the minds of pupils. A physics course of more enduring benefit to pupils is much concerned with understandings, implications and applications. Obviously such a treatment of physics requires more time than is at present allotted to the subject by most schools. Furthermore, the syllabus is absurdly out of date: outside of it lies a vast territory which is particularly interesting and fruitful dealing with the modern discoveries and applications of physics such as the invisible spectrum, radio, X-rays the photo-electric cell, the sound film, television and all that fascinating borderland between physics and the fields of chemistry, astronomy, engineering and biology. Here is an

expanding universe of ideas which deserves an increasing amount of attention in the physics course.

It is fair to state that the present move for more freedom of action on the part of teachers of school physics is not essentially on attack on college domination, the present syllabus or the recent examinations of the College Entrance Examination Board but it rises from a sincere desire to improve the quality of the teaching of physics.

Our own association seems to be opposed to the plan of reducing the load by omitting one of the main divisions of the subject, for reasons which previous speakers have presented. It has also been shown in the discussion that the counter-proposition of a two-year course, excellent in itself, has but small chance for general adoption.

I wish to suggest several other possible relief measures. (a) With the coöperation of the teacher of general science certain of the easier topics of physics may be pushed into the lower grades and be given much less time in the physics course. (b) Some teachers believe that much time can be saved by placing less emphasis on mathematical computations and by indicating in the syllabus the topics which are to be treated mathematically. (c) It may be wise to condense and reduce the treatment of mechanics which at present in most school physics courses requires more than one third of the year. (d) A joint committee of teachers of school and college physics might make a study of the relation of school and college physics with a view to developing better articulation between them. If such a committee revised the present syllabus they might be able to redistribute the load and give some relief to the school course and at the same time inform college teachers as to what topics they may reasonable expect the college freshman to have mastered in his school physics.

The address on "The Measurement of Color" by Prof. Arthur C. Hardy of the Massachusetts Institute of Technology centered around the demonstration of the new photoelectric color analyzer. Prof. Hardy explained and illustrated the principles of the process by means of lantern slides. He then described in detail the construction of the color analyzer and finally put it into operation so that we could watch it drawing the curve for the color of a sample of cloth that was being analyzed. The process is not only exact but it saves much time formerly required for observations and computations and is becoming of increasing usefulness in a large number of commercial applications.

SOME FUNDAMENTAL PRINCIPLES OF ELECTRICAL COMMUNICATION

MR. J. W. HORTON, *General Radio Company*

Electrical communication stands in a somewhat unique position among the contributions of the so-called machine age to civilization. Until the advent of radio broadcasting, none played its part so unobtrusively. Modern transportation, for example, hides little behind the scenes; whereas, in the case of telephony, it has been estimated that of the total physical equipment necessary for a given conversation less than 3% is ever seen by those for whom the service is provided. While locomotives, roundhouses and switch towers are much in evidence to the commuter,

there is little indication of the existence of elaborate machine switching plants, toll test boards or repeater stations to the average telephone subscriber.

Each of us has a fairly definite mental picture of the relative capabilities of a freight train and of a wheel-barrow for the conveyance of ponderable matter. It is not so easy to think in quantitative terms of the performance of electrical communication systems because the commodity with which they deal is of an intangible nature. It would appear desirable, however, especially at a time when economic values are of such pressing importance, that we have some appreciation of the magnitude of the burden imposed on the system in the various forms of electrical communication now receiving attention. For example, any householder who has provided for lighting his home electrically is not surprised to learn that it would be necessary to increase the energy-carrying capacity of the mains connecting him with the central station should he decide to heat electrically as well. The same householder, however, is quite likely to lend a credulous ear to the rumor that he may expect in the near future, simply by adding some fixtures to his present telephone instrument, both to see and hear the person with whom he is connected.

The first step in discussing communication systems quantitatively is to discover the commodity with which they deal. It is certainly true that our interest in the telephone line for which monthly charges are paid is not primarily in the electrical energy which it delivers, but in the information which it conveys. We care little about millivolts or microwatts, but are deeply concerned with invitations to dinner and orders to the grocer. For want of a more suitable term, then, we may call this commodity "information." The physical aspects of information take many forms which may be classified, for convenience, in terms of the senses with which we perceive them. Electrical communication systems have been developed and are in use for two classes, namely, audible and visual. At first sight there appears little in common between what we hear and what we see, which may be used as a common basis for comparing their relative values. It is true that the Chinese have long maintained that one picture is worth a thousand words. This estimate, however, appears to have been based entirely on philosophical considerations. The most convenient method for quantitatively evaluating information is to be found in the technique of electrical communication itself.

Briefly, the operation of an electrical communication system may be described as follows. The information which it is desired to convey acts through the agency of some suitable device at the sending end in such a way that certain characteristics are imparted to an electric current. This current is then conducted over the connecting transmission medium to the distant end where it controls the operation of some receiving device in such a manner that a reproduction of the original information is made available. It is not accurate, therefore, to say that you heard someone's voice over the telephone. What you heard was a reproduction of that

voice by an electroacoustic instrument acting under the control of an electric current. It is apparent from the above that during the process of transmission the information with which we are concerned is identified with certain characteristics of an electric current. The characteristic most generally used for this purpose is the variation of the amplitude of the current with time.

This idea is beautifully exemplified by the electric telegraph. Here the problem is to convey information having a form analogous to that of writing. It is necessary, therefore, to find some property of such information which may be expressed in terms of the varying amplitudes of an electric current. The solution to this problem is the telegraph code, invented by Morse. This code is nothing more nor less than a system of writing in which the vertical height of the inscribed line has never more than one value for any given horizontal position. Consequently, as this line is scanned horizontally there is encountered at any instant a definite and single value of vertical height. It is this property alone which constitutes the essential difference between the Morse code and our more familiar forms of written or printed information. By virtue of this characteristic Morse writing may be completely identified with an electric current by causing the latter to pass through a succession of intensity values corresponding to the succession of vertical heights encountered as the line is scanned. To one familiar with this method of writing, a message may be read equally well by looking at the script or by observing with some suitable instrument the amplitude variation in the electric current. If desired, the current may be used at the receiving end of a telegraph line to operate a mechanism for the reproduction of a facsimile of the original script.

In the case of telephony the problem is more direct. Sound may be completely described in terms of the variation with time of the air pressure at a given point. It is merely necessary, therefore, to provide at the sending end a device by which the amplitude of an electric current is determined by the air pressure, and at the receiving end a device by which the pressure of an emitted sound wave is determined by the amplitude of this current. In this way the pressure variations at the distant end of a line are made to reproduce those existing at the sending end.

If the reproduction of the original sound is to be faithful, it is necessary that the variations in the electric wave carried by the transmitting medium whether wire line or radio channel, correspond faithfully to the variations in the original sound pressure. This is true regardless of the complexity of the original sound. For example, we know that the sound emitted by a given musical instrument is made up of a fundamental tone and a series of over-tones. For each of these pure tones the variations in air pressure are sinusoidal. A distinguishing feature of any sinusoidal variation is the frequency with which it is repeated. In the case of a sound wave it is this frequency of repetition which determines the pitch of the tone. The sound wave set up by a complete orchestra, as well as that set up by a single

instrument, may be considered as the summation of a large number of these pure tones or sinusoidal variations. Consequently, since every pressure variation of the sound wave is followed by the amplitude variations of the electric current, the latter may be considered likewise as the summation of a number of sinusoidal alternating currents. As we shall see later, the frequencies of these individual components are of considerable importance.

Passing now to the problem of visual information, we find an interesting combination of the principles of telephony and of telegraphy. Here, as in the previous cases, the problem is to find some characteristic of a visual image which may be shared by an electric wave. If we regard a picture as being made up of a number of discrete elementary areas each of uniform tone density, we have merely to scan these in sequence to obtain a succession of tone values, each of which may be identified with the amplitude of an electric current. In a picture transmission system, for example, a negative at the sending end is scanned by means of an optical system containing a photo-electric cell. At any instant the current through this cell is proportional to the intensity of the light transmitted through that particular portion of the negative at that instant under scrutiny. At the receiving end a somewhat similar optical system is provided. Here the intensity of the illumination falling upon a sensitized photographic surface is controlled by the amplitude of the received current and there results a positive print. Through the medium of the electric wave the negative at the transmitting end has determined the light falling upon any portion of the positive print just as truly as though they were in contact in a conventional printing frame.

Having succeeded in translating both sound and image into electric waves, it is apparent that we are approaching a common basis for comparison. We have already seen, in the case of telephony, that the electric wave present in the transmitting medium may be considered as made up of a number of individual sinusoidal components each having its own characteristic frequency. This is equally true of the wave present in a picture transmission system, although here we have no familiar counterpart in the original form of the information. The frequencies of the sinusoidal components of the transmitted wave are of considerable importance to the communication engineer, inasmuch as they determine to a considerable extent certain pertinent characteristics of the transmission medium.

In order to correlate the amount of information with the components of a wave, let us imagine that certain spoken words are recorded phonographically. This serves to give to the information, existing originally as an air wave, a permanence of form which will preserve its identity throughout any experiments which may be made with it. If, now, this record be driven normal speed, the wave may be converted into the electrical form by an electromechanical pickup device. This electrical wave may be analyzed and the frequencies of its sinusoidal components determined. As might be expected, these are found to agree with the constituent pure

tones of the original sound, It will be observed that the frequencies of these components fall within a region to the limits of which may be assigned definite maximum and minimum values. Now let us drive the record at twice its normal speed. If we care to repeat the analysis, we will find a confirmation of what our intuition has already told us: the frequency of each individual component has been doubled. Inasmuch as this applied to the frequencies terminating the region occupied by the entire group, it is evident that the numerical extent of the frequency range has been doubled likewise. Were we to drive the record at half-speed, we should find that the numerical extent of the frequency range is halved. In other words, the frequency range occupied by the components of the wave obtained from the pickup device is strictly proportional to the speed at which the record is run. Thus, remembering that the total amount of information is the same in each case, and hence that the speed is a direct measure of the rate at which it is transmitted, we arrive at a fundamental theorem of electrical communication, namely; *The rate at which information is transmitted over a wave communication system is directly proportional to the extent of the requency range occupied by the sinusoidal components of the signal wave.*

From this theorem may be obtained directly the useful corrolary; *The production of the frequency range occupied by the sinusoidal components of a signal wave and the time required for its transmission is a numerical measure of the amount of information contained therein.*

We now have available all the technique required for evaluating any given amount of information. It remains to collect certain pertinent data.

Long experience with telegraph systems has shown that it is necessary to preserve harmonic components having frequencies somewhat greater than three times the rate at which individual letters are being transmitted. Assuming that there are on the average five letters per word in normal telegraph text, we obtain, by applying our second theorem, the number 15 as an index measure of the information value of a single word in telegraph code.

In telephony it is desirable to retain components having frequencies as high as 3,000 cycles per second for normal conversation, or 10,000 cycles per second for the high quality transmission necessary in broadcasting. Assuming a rate of one hundred words per minute for normal speech, we find that the index number for a single spoken word is somewhere between 1,500 and 2,000. To evaluate visual information we may refer to data pertaining to the picture transmission system now in use by the A. T. & T. Co. The equipment provided for these transmissions is designed to scan a 5×7 photograph by a series of lines 1/100th inch wide. These in effect resolve the picture into 350,000 separate elementary areas. The component of highest frequency which could be encountered would occur when adjacent elements are alternately dark and light. This would give one complete cycle of tone variation for every two elements, or 175,000 cycles per picture. This figure is the significant index number referred to in our theorem.

On the basis of somewhat arbitrary assumptions as to representative forms of audible and visual information, we have arrived at a comparison of the two. We see that a typical 5×7 photograph is equivalent in information content to one hundred spoken words. Apparently the ancient Chinese philosopher, like the modern school boy, was right *except for the decimal point.*

TABLE I

This shows the relative amounts of information contained in the various forms of information listed. These are orders of magnitude only; in each form a wide spread will be found in practice.

	Index Number
One word in telegraph code	15
One spoken word—as transmitted by telephone	1,800
One second of orchestral music	20,000
One normal 5″ by 7″ photograph	175,000
A television image—present state of the art	1,200

TABLE II

This shows the relative information-carrying capacity of various forms of electrical communication channels. As in Table I the values given are representative rather than rigorously accurate.

	Frequency Band In Cycles Per Second
Early Forms of Transatlantic Cable	15
Early Forms of Transatlantic Cable	15
Present High-Speed Transatlantic Cable	125
Subscribers' Loop Connecting to Central Office	3,000
Toll Cable Circuit	2,800
Open Wire Line—Equalized	30,000
Transatlantic Radio Telephone Channel—Long-Wave	3,000
Radio Broadcast Channel	10,000
Short-Wave Broadcast Channel	150,000

In view of the many startling predictions made in connection with television, it may be interesting to apply our technique to an evaluation of the transmission problem involved. Here the question of rate reappears as we are confronted with the necessity of completing the transmission of a single image in approximately 1/20th of a second. If there are required 175,000 cycles—not cycles per second—for the reproduction of the 5×7 photograph which we have already used as a typical picture, it follows at once, if the transmission is to be completed in the 1/20th of a second, that the resulting electrical wave will contain sinusoidal components covering a band 3,500,000 wide. In other words, a television system capable of producing an image comparable to a good 5×7 photograph would be required to transmit information at a rate one thousand times greater than that needed for telephony. In view of the fact that no electrical transmission system has been developed capable of accommodating so extensive a frequency range, designers of television systems have been obliged to content themselves with an image decidedly inferior to that which we have chosen as an example. In general, the various television systems reproduce an

image comparable in details to an ordinary newsprint portrait one-inch square. They are composed of approximately fifty scanning lines, and thus contain only 2,500 elements. This gives an information index number of 1,200—less than for a single spoken word. If this information is to be transmitted at the rate of twenty images per second, our fundamental theorem tells us that the transmission system must be capable of accommodating a frequency band 25,000 cycles wide.

With the requirements which the various forms of information impose on their respective electrical communication systems in mind, the capabilities of various representative types of transmitting media have been listed in Table 2. It will be recalled that the width of the frequency band in cycles per second is directly porportional to the rate at which the system is capable of transmitting information. An examination of this table seems to throw some doubt on the prospect of utilizing our present telephone network for both television and telephony. Not only is the circuit connecting individual subscribers with the central office already loaded to capacity with the speech transmission, but it fails by a factor of at least ten of having the information-carrying capacity needed for even the crudest television image. Furthermore, we must not forget the fact, in considering communication between two individuals, that in telephony we are generally willing to take turns in listening to each other; whereas it is doubtful if we should be willing to take turns in looking at each other. Hence, in addition to the simple fixture which it has been predicted may soon be soon be added to our telephone instrument, it is apparent that the information-carrying capacity of the circuits would have to be increased approximately twenty times above those now available.

As an examination of Table 2 would lead one to believe, the most promising medium for television at present appears to be by means of short-wave radio. Practically all effort toward television is being concentrated on this type of transmission, and while it is undoubtedly true that for some time longer the smile will have to depend upon the voice for its transmission, as far as our telephone conversations are concerned, it is quite probable that some practical form of television may be worked out in connection with short-wave broadcasting.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions:

1. Drawings in india ink should be on a separate page from the solution.

2. Give the solution to the problem proposed if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1257. *Albert Schwartz, Perth Amboy, N. J.; H. R. Mutch, Glenn Rock, Pa.*

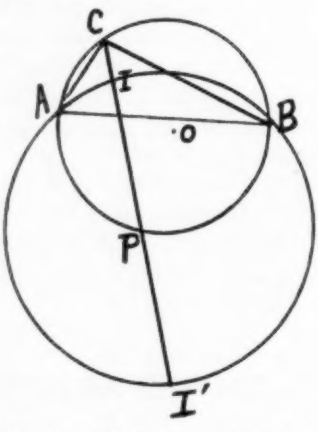
1259. *Boris Garfinkel, Buffalo, New York.*

1262. *Proposed by W. E. Batzler, Battle Creek, Mich.*

Given the position of the circumcenter, an excenter, and the incenter, construct the triangle.

Solved by Albert Schwartz, Perth Amboy, N. J.

Given the points I, I', O the positions of the incenter, one excenter and the circumcenter respectively. Draw II' and bisect it in P and with P as center and PI as radius describe circle. With O as center and OP as radius describe circle. Extend II' to meet this circle in C. Draw the common chord AB. Then ABC is required triangle.



Proof: The angles IAI' and IBI' are right angles, hence the circle on II' as diameter passes through A and B. Since II' is the internal bisector of Angle C it passes through the midpoint of AB. But the midpoint of the arc lies on the perpendicular bisector of AB. Hence P lies on circumcircle of $\triangle ABC$ and OP is the circumradius.

Also solved by Norman Auning, University of Michigan, O. B. Kraemer, Battle Creek, Iowa, W. E. Buker, Leetsdale, Pa., John E. Bellards, St. Nazianz, Wis., H. R. Mutch, Glen Rock, Pa.; and David Gordon, Brooklyn College.

1263. *Proposed by W. E. Buker, Leetsdale, Pa.*

Give a general method for finding integers a, b, c, d, e, f so that simultaneously $a+b+c=d+e+f$ and $a^2+b^2+c^2=d^2+e^2+f^2$.

Solution by F. A. Cadwell, St. Paul, Minn.

Let a, b, d, e be four known integers. The problem is to find two other integers, c and f, so that:

$$a+b+c=d+e+f \tag{1}$$

$$a^2+b^2+c^2=d^2+e^2+f^2. \tag{2}$$

Subtracting (2) from the square of (1), leaves a remainder of:

$$2ab+2(a+b)c=2de+2(d+e)f. \tag{3}$$

Dividing (3) by 2, gives:

$$ab+(a+b)c=de+(d+e)f. \tag{4}$$

From (1) we get:

$$f=(a+b)+c-(d+e). \tag{5}$$

Substituting this value of f in (4) we have:

$$ab+(a+b)c=de+(a+b)(d+e)+(d+e)c-(d+e)^2. \tag{6}$$

Transposing terms in (6), we have:

$$[(a+b)-(d+e)]c=de-ab+(a+b)(d+e)-(d+e)^2. \tag{7}$$

Dividing both members of (7) by $(a+b)-(d+e)$, we obtain:

$$c=d+e+\frac{de-ab}{(a+b)-(d+e)}\cdot \tag{8}$$

Since a, b, d and e are known, c can be found. Having found c, f may be found by subtracting $d+e$ from $a+b+c$; or f may be found by using the following formula obtained by the method used in obtaining the formula for c:

$$f=a+b+\frac{ab-de}{(d+e)-(a+b)}\cdot \tag{9}$$

Applying the formula (8) to the example stated in the problem, suppose we have given $a=17$, $b=21$, $d=16$, $e=23$, to find c and f:

$\dfrac{de-ab}{(a+b)-(d+e)}=\dfrac{368-357}{38-39}=-11$. Also $d+e=39$. Therefore $c=28$ and $=27$.

The same procedure applied when $a=10$, $b=13$, $d=8$, $e=16$ yields $c=26$ and $f=25$.

If applying the formula to any set of integers a, b, d, e, produces fractions for c and f, then a set of integers complying with the conditions of the problem can be found by multiplying by the denominator of the fraction. For example, let $a=9$, $b=3$, $d=10$, $e=8$. Using the formula we find $c=55/6$, $f=19/6$. Multiplying by 6 we obtain $a'=54$, $b'=18$, $c'=55$, $d'=60$, $e'=48$, $f'=19$, which is a set of integers complying with the conditions of the problem.

The formula fails if $a+b=d+e$ and if $ab=de$.

If $a+b+c=d+e+f$ (1) and $a^2+b^2+c^2=d^2+e^2+f^2$ (2), then $(a\pm n)+(b\pm n)+(c\pm n)=(d\pm n)+(e\pm n)+(f\pm n)$ and $(a\pm n)^2+(b\pm n)^2+(c\pm n)^2=(d\pm n)^2+(e\pm n)^2+(f\pm n)^2$.

a	b	c	d	e	f
1	11	10	7	13	2
2	12	11	8	14	3
3	13	12	9	15	4
4	14	13	10	16	5

Therefore a table might be made of sets of integers complying with the

conditions of the problem by first finding one set of such integers and then adding or subtracting 1 to each integer of the set, then adding or subtracting 1 to each integer of the new set so found, and so on as above.

The proposer gives the following references to this problem:

Sphinx, March, 1932, pp. 39 and 40, and April, 1932, p. 53.
Dickson, History of the Theory of Numbers, Vol. II.
Dickson, Introduction to the Theory of Numbers.
Carmichael, Diophantine Analysis.

Also solved by John E. Bellards, St. Nazianz, Wisconsin; and the proposer.

1264. *Proposed by Lambert E. Brood, Aliquippa, Pa.*

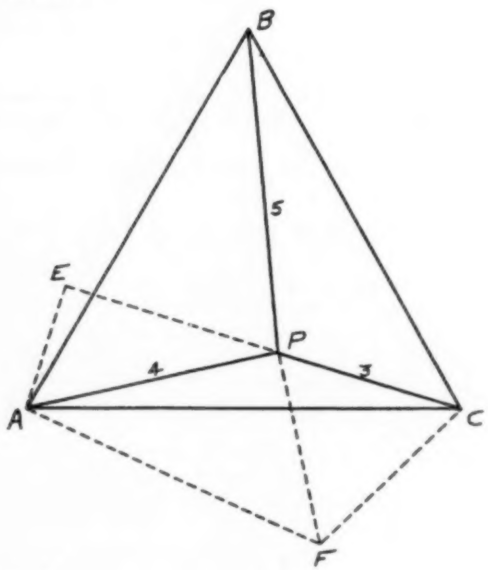
Three segments, one from each vertex of an equilateral triangle, meet at a point within the triangle in the ratio of 3:4:5. What is the length of the side of the equilateral triangle?

FIRST SOLUTION:

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

In the $\triangle ABC$, $PC:PA:PB=3:4:5$.
Let 1/3 PC be the unit of measurement.
On PC as a side, construct the equilateral $\triangle PCF$.
Draw $AE \perp CP$ produced. Join A and F.

1. $\angle BCP + \angle PCA = 60°$
2. $\angle ACF + \angle PCA = 60°$
3. $\angle BCP = \angle ACF$
4. $PC = CF$
5. $BC = AC$
6. $\triangle BCP \cong \triangle ACF$



7. $BP = AF = 5$
8. $PF = PC = 3$
9. $\overline{AF}^2 = \overline{PF}^2 + \overline{AP}^2$
10. $\angle APF = 90°$ (Converse of Pythogorean proposition.)

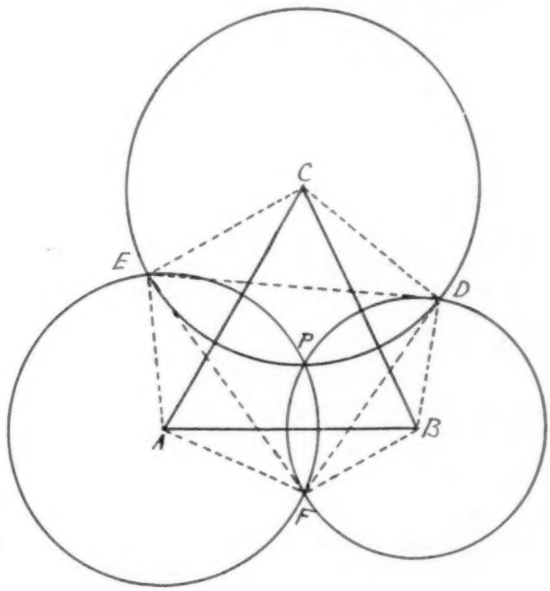
11. $\angle FPC = 60°$
12. $\angle APE = 30°$
13. $AE = \frac{1}{2}AP = 2$
14. $EP = \sqrt{\overline{AP}^2 - \overline{AE}^2} = 2\sqrt{3}$
15. $\overline{AC}^2 = \overline{AP}^2 + \overline{PC}^2 + 2 \cdot PC \cdot EP$
16. $AC = \sqrt{16+9+12\sqrt{3}} = 6.7664$

i.e. $PC:PA:PB:AC = 3:4:5:6.7664$.

SECOND SOLUTION:

By W. E. Buker, Leitsdale, Pa.

The data is insufficient to find the actual side of the triangle. However, if the triangle is ABC and the interal point P, let $AP = 4m$, $BP = 3m$, and $CP = 5m$. With centers A, B, C, and radii $4m$, $3m$, $5m$, respectively, draw circles intersecting at P. Circles A, C, intersect at E; circles A, B at F, and circles B, C at D. Draw EA, EC, FA, FB, DB, DC.



Angles EAC and PAC are equal; also FAB and PAB. So, $\angle EAF = 2\angle CAB = 120°$

Similarly, $\angle FBD = \angle DCE = 120°$.

Moreover, $\triangle AFB \cong \triangle APB$, $\triangle BDC \cong \triangle BPC$, and $\triangle AEC \cong \triangle APC$, so that $AFBDCE = 2\triangle ABC$.

$EF = 4m\sqrt{3}$, $FD = 3m\sqrt{3}$, $DE = 5m\sqrt{3}$

$\therefore$ Area of $\triangle EAF = 4m^2\sqrt{3}$; Area of $\triangle FBD = \frac{9m^2}{4}\sqrt{3}$; Area of $\triangle DCE = \frac{25m^2}{4}\sqrt{3}$; Area of $\triangle EFD = 18m^2$ (By Hero's Formula)

$\therefore$ Area of $AFBDCE = 18m^2 + \frac{25m^2}{2}\sqrt{3} = 2\times$ Area of $\triangle ABC$.

$\therefore$ Side of $\triangle ABC = m\sqrt{12\sqrt{3}+25} = 6.77m$.

NOTE: The above solution follows one of a similar problem in *Mathematical Nuts*, S. I. Jones, pp. 294–5. A trigonometrical solution, the method of which is quite obvious, is given there. The algebra becomes somewhat involved.

Also solved by F. A. Cadwell, St. Paul; Norman Auning, University of Michigan; and William W. Johnson, Cleveland, Ohio.

1265. *Proposed by Nathan Micholson, Philadelphia, Pa.*

Given a circle, O, with chord AB and C its mid point. Through C draw any two chords DE and FG. Draw lines DG and FE intersecting chord AB at M and N respectively. Prove by methods of elementary geometry that $MC = NC$.

Three incomplete solutions were received.

1266. *Proposed by O. T. Snodgrass, Columbia, Mo.*

Given a sphere of radius, a, and a square shaft, with a side of a cross section of the square, x. Find the volume cut out by this shaft whose central axis passes through the center of the sphere.

No solution has been offered.

1267. *Proposed by Walter Carnahan, Indianapolis, Ind.*

Construct the triangle ABC given the points C and A and the lengths of the lines joining A to the centroid G and to the orthocenter H.

No solution has been offered.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

CORRECTION

A mathematical truth is not decided by majority vote. In solving problem 1255 in the February issue, several contributors agreed to the results as published. Mr. Trigg, however, submits a solution showing an error in the results. His solution and discussion follows:

1255. *Proposed by Charles Louthan, Columbus, Ohio.*

The combined surface area of a sphere and cube is to be minimized while keeping the combined volume constant. Find the ratio of the radius to the edge.

Correction by Charles W. Trigg, Cumnock College, Los Angeles, California.

The solution published in the February, 1933, issue is in error in giving the ratio for a maximized surface.

Since the sphere is the geometric solid which encloses a given volume with a minimum surface, the minimum combined area will be attained when all of the volume is enclosed in the sphere. For this condition, the ratio of radius to edge is $\frac{r}{0} = \infty$.

The relationship may be more rigidly developed by letting r = radius, e = edge, V = combined volume, and A = combined surface area.

Then $V = \frac{4}{3}\pi r^3 + e^3$ and $r = \sqrt[3]{\frac{3}{4\pi}(V - e^3)}$

$$A = 4\pi r^2 + 6e^2 = 4\pi\left(\frac{3}{4\pi}[V-e^3]\right)^{2/3} + 6e^2$$

$$\frac{dA}{de} = -6e^2\left(\frac{3}{4\pi}[V-e^3]\right)^{-1/3} + 12e$$

$$\frac{d^2A}{de^2} = 12 + 6\left[\frac{9e^4}{4\pi}\left(\frac{3}{4\pi}\{V-e^3\}\right)^{-4/3} - 2e\left(\frac{3}{4\pi}\{V-e^3\}\right)^{-1/3}\right]$$

Equating $\frac{dA}{de}$ to zero and solving, gives $e=0$ and $\sqrt[3]{\frac{6V}{\pi+6}}$.

Substituting these values of e in $\frac{d^2A}{de^2}$, we find when $e=0$, $\frac{d^2A}{de^2} = +12$ whence $e=0$ gives a minimum surface, and $\frac{r}{e} = \frac{r}{0} = \infty$. When $e = \sqrt[3]{\frac{6V}{\pi+6}}$, $\frac{d^2A}{de^2} = 12 + 6\left[\left(\frac{9}{4\pi} - 1\right)(8)^{4/3}\right] = -15.244$ (approx.), whence the surface for this value of e is a maximum. Solving the expression for r with this value of e, yields the ratio $\frac{r}{e} = \frac{1}{2}$ for the maximized surface.

By eliminating e from the original equations and differentiating with respect to r, the maximum values obtained are the same, but a minimum is secured for $r=0$, whence $\frac{r}{e}=0$. That this minimum is larger than the one secured for $e=0$ may be easily shown by substituting these values in the original equations and solving for A.

When $e = \sqrt[3]{\frac{6V}{\pi+6}}$, $A = \sqrt[3]{36(\pi+6)}\,V^{2/3} = 6.904V^{2/3}$ (max.). When $r=0$, $A = 6V^{2/3}$ (minimum); when $e=0$, $A = \sqrt[3]{36\pi}\;V^{2/3} = 4.836V^{2/3}$ (absolute minimum). Therefore, when the surface is minimized, $\frac{r}{0} = \infty$. That is, the ratio is indeterminate.

NOTE. Mr. Trigg calls attention to value of $\frac{d^2A}{dr^2} = 8\pi - 16\pi\left(\frac{\pi}{12}+1\right)$ which is obtained by some labor after replacing r by its value in terms of V.—EDITOR.

PROBLEMS FOR SOLUTION

1280. *Proposed by Frank B. Allen, Sparta, Ill.*

Find the sum of the series: $1 - 1/5 + 1/7 - 1/11 + 1/13 - 1/17 + \cdots$.

1281. *Proposed by Charles Louthan, Columbus, Ohio.*

A vessel is anchored a miles off shore. Opposite a point m miles farther along the shore, another vessel is anchored b miles from the shore. A boat from the first vessel is to land a passenger on the shore and then proceed to the other vessel. Find the shortest course of the boat.

1282. *Proposed by Albert Schwartz, Perth Amboy, N. J.*

Bisect a triangle by the shortest possible line.

1283. *Proposed by William H. Godson, Jr., Narberth, Pa.*

To construct a circle such that both tangents from a given point shall be 10 units in length, and the larger arc between points of tangency shall also be 10 units in length.

1283. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles, Calif.*

If two internal bisectors of a triangle are equal, the triangle is isosceles. Prove by a direct method, or demonstrate that a direct proof is impossible.

Any indirect proofs by methods other than those given in Altshiller-Court and Todhunter will be considered.

1284. *Proposed by S. Chnang, Ping-yang-fu, Shausi, China.*

Solve the pair of equations:

$$xy = x^2 - y^2$$
$$x^2y^2 = x^3 + y^3$$

BOOKS RECEIVED

Number the Language of Science, by Tobias Dantzig, Professor of Mathematics, University of Maryland, Lecturer on Mathematical Physics, U. S. Bureau of Standards. Second Edition Revised. Pages viii+262. 14 x 21.5 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Prices $2.50.

My Subtraction Drill Book, by Guy M. Wilson, Professor of Education, Boston University. Paper. Pages vi+49. 21 x 28 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

We Look About Us, by Gerald S. Craig, Assistant Professor of Natural Sciences, Teachers College, Columbia University, and Agnes Burke, Teacher in Horace Mann School and Instructor in Kindergarten—First Grade Education, Teachers College, Columbia University. Cloth. Pages v+194. 13 x 19 cm. 1933. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price 68 cents.

Introduction to Practical Astronomy, by Dinsmore Alter, Professor of Astronomy, University of Kansas. Cloth. Pages viii+80+48. 19 x 25.5 cm. 1933. Thomas Y. Crowell Company, 393 Fourth Avenue, New York, N. Y. Price $2.00.

Mathematical Excursions, by Helen Abbot Merrill, Professor of Mathematics, Emeritus, in Wellesley College, Wellesley, Mass. Cloth. Pages xi+145. 13.5 x 19.5 cm. 1933. Helen A. Merrill, 6 Waban Street, Wellesley, Massachusetts. Price $1.75.

PAMPHLETS RECEIVED

Bibliography of Research Studies in Education, 1930–1931. Bulletin, 1932, No. 16. Prepared in the Library Division Office of Education by Edith A. Wright with the cooperation of Ruth A. Gray. Pages xviii+459. 15 x 23.5 cm. For sale by the Superintendent of Documents, Washington, D. C. Price 50 cents.

National Survey of the Education of Teachers. Volume I, Selected Bibliography on the Education of Teachers. Bulletin 1933, No. 10. Compiled by Gilbert L. Betts, Benjamin W. Frazier, and Guy C. Gamble. Pages xi+118. 14 x 23 cm. For sale by the Superintendent of Documents, Washington, D. C. Price 15 cents.

Coöperative Experimentation in Materials and Methods in Secondary School Physics, by Archer Willis Hurd, Institute of School Experimentation, Teacher's College, Columbia University with Foreword by Otis W. Caldwell, Director, Institute of School Experimentation, Teachers College, Columbia University. Pages ix+60. 15 x 23 cm. Bureau of Publications, Teachers College, Columbia University, New York City. Price 60 cents.

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The following extracts from a review in School Science and Mathematics written by the editor speak for themselves:

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SAMUEL I. JONES, Author and Publisher
Life and Casualty Bldg., Nashville, Tenn.

the co-operation of the Subcommittee on Political Education of the American Political Science Association. 32 pages. 12.5 x 19 cm. 1933. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Ill. Price 10 cents.

Telling Time Throughout the Centuries, prepared under the Auspices of the Committee on Materials of Instruction of the American Council on Education with the co-operation of the Subcommittee on Political Education of the American Political Science Association. 64 pages. 12.5 x 19 cm. 1933. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Ill. Price 20 cents.

Rules of the Road, prepared under the Auspices of the Committee on Materials of Instruction of the American Council on Education with the co-operation of the Subcommittee on Political Education of the American Political Science Association. 32 pages. 12.5 x 19 cm. 1933. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Ill. Price 10 cents.

Instruction in Science, by Wilbur L. Beauchamp, Assistant Professor of Education at the University of Chicago. Bulletin 1932, No. 17. National Survey of Secondary Education, Monograph No. 22. Pages vi+63. 15 x 23 cm. For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents.

BOOK REVIEWS

The Relativity Theory Simplified, by Max Talmey, M.D. with an Introduction by George B. Pegram, Professor of Physics, Columbia University. Cloth. Pages xi+186. 12.5 x 19 cm. 1932. Falcon Press, Inc., 1451 Broadway, New York. Price $1.50.

In the introduction to this book Professor George B. Pegram says:

"The author writes as a teacher gifted in logical but simple exposition. He leads the reader through the subject by those paths, some of his own making, that he has himself found straightest and easiest. While this book is for laymen to read and understand, it will be none the less useful to students of physics and to teachers of the subject."

This is an excellent, brief description of the book except for the one word, layman. Even if we amend the expression to 'educated layman' it will not do, because to understand the relativity theory requires considerable knowledge of physics—a knowledge which few educated laymen have. The reviewer prefers to emphasize the last thought in the quotation namely, that the book will be useful especially to students and teachers of physics in understanding the theory of relativity and in studying the evidence supporting it.

The author has made a careful study of the experiments in mechanics, optics, spectroscopy, astronomy, etc. which led to the publication of the theory and the tests that have been applied to it. He has briefly described these experiments, leaving out all unnecessary details, and has shown how they are related to the relativity theory. To do this in non-technical language and with no mathematics except very elementary algebra is no small accomplishment, but in a few cases he has frankly confessed that an adequate discussion demands the use of more complicated mathematics. The book is valuable in clearing up some of the erroneous ideas, due to misinterpretation of the language of the original papers, that have been introduced into other attempts to write popular explanations of the theory. Examples of this are the misunderstandings of the terms "fourth dimension" and "curved space."

In places the explanations given will lead to misconceptions; e.g. the illustration of Doppler's principle on page 61 is erroneous as applied to sound but its application to the shifting of spectral lines on the following page is correct. Also on page 90 the author states: "The kilogram-meter is the work done when a kilogram of mass is lifted through a height of one meter." Just preceding this sentence he has explained that the earth does not pull with a kilogram of force on a kilogram of mass at all places. On page 94 it is stated that "1 billion $=10^{12}$". A billion dollar budget or war debt according to American use has not yet reached such a sum. If the presentation is for the layman, the language used must be the language he understands.

Part III tells of the early life of Albert Einstein, and is well worth the price of the book. Dr. Talmey, while a medical student at Munich, became acquainted with the boy Einstein, visited in his home and assisted him in his first science studies, hence he is able to give us an interesting biography of the early years of the great mathematician.

G. W. W.

Radio Servicing Course, by Alfred A. Ghirardi, Department of Radio Communication and Applied Electricity, Hebrew Technical Institute, New York City and Berthram M. Freed, Consulting Radio Service Engineer. 110 Illustrations. First Edition. Cloth. Pages ix+182. 19 x 12.5 cm. 1932. Radio Technical Publishing Co., 22 West 21st Street, New York City. Price $1.50.

"Be your own radio service man" might be the sales slogan for this book. By its guidance anyone of average intelligence and a very elementary knowledge of electricity can soon become skilled in adjusting and repairing radio equipment, for it is a complete course in servicing modern radios and radio apparatus. It is a well-arranged textbook, suitable for either class instruction or for home study, giving the theory of electrical measurement and clear explanations of the various types of meters in common use. Following the general discussion of measurement and testing the specialized instruments making up the set analyzer are explained and directions given for locating receiving trouble. This section has received minute attention and should enable the student to detect and correct all ordinary faults in receivers. The elimination of noise and checking vacuum tubes are discussed in detail.

In addition to its value as a technical text, the book is valuable for general electricity reference and study. It contains much practical information and many good diagrams, and gives the needed assistance in the use of radio devices now so extensively used in many types of research.

G. W. W.

Arithmetic for Teachers, by Harriet E. Glazier, Department of Mathematics, University of California at Los Angeles. First Edition. Cloth. Pages xv+291. 13.5 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.00.

This book is designed for students qualifying to teach in elementary schools. Thus the purpose of the course is to give the student a connected idea of the subject matter of arithmetic; the concept of number; the development of a number system; the four fundamental operations with natural numbers, or integers, those numbers at which we arrive by the simple process of counting; the fractional or artificial number in its various forms, the common fraction, the decimal fraction, the per cent, and the extension of the four fundamental operations to include them; the fundamental idea of a unit of measure and the endless field of measurement; as well as those notions of space—length, surface, volume—which were